HYDROLOGIC-HYDRAULIC AND ENVIRONMENTAL ASSESSMENT FOR THE CAMP KEAIS STRAND FLOWWAY

Prepared for
South Florida Water Management District
Big Cypress Basin

Contract No. PC P502113

August 2006

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Prepared for

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August 2006

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ATM	Applied Technology and Management, Inc.
PSRP	Picayune Strand Restoration Project
CAD	computer assisted drawing
cfs	cubic feet per second
CKS	Camp Keais Strand area a submodel
DEM	digital elevation model
DHW	design high water elevation
DRI	Development of Regional Impact
FLUCCS	Florida Land Use, Land Cover Classification System
ft	feet
FU-2	Faka Union Canal
GIS	Geographic Information System
HGL	HydroGeoLogic, Inc.
Merritt-1	Merritt Canal
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
PIR	Project Implementation Report
POI	period of interest
Prairie-1	Prairie Canal
RET	reference evapotranspiration
SFWMD	South Florida Water Management District
TIN	Triangular Irregular Network
USACE	US Army Corps of Engineers

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1.0 INTRODUCTION AND PROJECT BACKGROUND

This report was prepared by HydroGeoLogic, Inc. (HGL) under contract PC P502113 with the South Florida Water Management District (SFWMD). The project encompassed a hydrologic-hydraulic and environmental assessment for the restoration of the Camp Keais Strand Flowway in central Collier County. The project was comprised of four tasks, the results of which are documented in this report:

Task 1: Data Collection
Task 2: Evaluation of Existing Conditions
Task 3: Development and Analysis of Alternatives
Task 4: Improvement Plan Recommendations

Substantial portions of the hydrologic-hydraulic modeling for Tasks 2 and 3 were performed by DHI, Inc. Task 4 was performed by Applied Technology and Management, Inc. (ATM), under the auspices of Mr. Robert Burleson, Professional Engineer, FL#42497.

Camp Keais Strand is a large natural slough in central Collier County conveying sheet flow through wetlands from Lake Trafford to Stumpy Strand, eventually discharging to Merritt Canal in Picayune Strand State Forest (Figure 1.1). Over the last fifty years, the historic flow pattern of the strand has been affected by roads and agricultural developments.

Presently two major structures cross the strand, one a bridge at Immokalee Rd. (CR 846) and the other a bridge at Oil Well Rd. (CR 858). In addition, there are a number of agricultural features (farm roads, ditches, dikes, and farm fields), which have altered the natural flow regime of Camp Keais Strand. These modifications to Camp Keais Strand have altered wetland hydroperiods, which have allowed the invasion of exotic species such as melaluca and Brazilian pepper.

The agricultural lands adjacent to Camp Keais Strand maintain decreased water table elevations by pumping out the farmed areas to onsite storage reservoirs which are generally connected to the Strand via a variety of farm structures. The extent of the dewatering and discharges into the Camp Keais Strand can create higher stages at certain times of the year and alter the water quality within the natural areas. Furthermore, proposed re-development of agricultural areas in adjacent to Camp Keais Strand are anticipated to cause additional alteration of the Camp Keais Strand natural system.

The Hydrologic-Hydraulic and Environmental Assessment of the Campa Keais Strand Flowway project was initiated to develop an action plan for the restoration of natural flow conditions within the Camp Keais Strand Area, which will ensure attenuation of flood peaks, water quality improvement, and long-term protection of the core wetland ecosystem stretching from Lake Trafford and the Florida Panther National Wildlife Refuge.

The objective of this study was to assess the hydrologic-hydraulic and environmental quality characteristic of Camp Keais Strand area from its source at Lake Trafford to I-75 and develop an implementable plan to restore the flowway.

2.0 DATA COLLECTION (TASK 1)

As part of the data collection phase a windshield survey of the existing flowway and current crossing facilities within the strand was conducted. The windshield survey included evaluation of accessible active and abandoned facilities that represent an alteration of the natural flowway. Facilities investigated included all accessible culverts, structures, crossing berms and dikes, farm roads, and major manmade obstructions within the basin. The windshield survey of farm facilities was augmented with computer assisted drawings (CAD) provided by Collier Enterprises and the New Town Development Plan (Wilson Miller, 2004).

The data collection efforts also consisted of evaluation of available meteorologic and hydrologic-hydraulic data for assessment of surface and groundwater characteristics of the basin. A comprehensive inventory of the vegetation to assess the functions of the wetlands was not performed because the available project budget was insufficient to do a detailed vegetation analysis. However, a land-use analysis using available GIS coverages to relate land-use classifications to hydrologic parameters was performed and is sufficient for the analyses performed in Tasks 2 and 3.

As part of the data collection phase, the most recently acquired aerial photogrammetric topography data was incorporated into the analyses performed in this study.

The following sections detail the results of data collection phase.

2.1 SURVEY OF FLOWWAY AND CURRENT FACILITIES

The location of structures and features identified during the windshield survey and/or through analyses of the aerial photographs for the area are shown in Figure 2.1. The structure locations identified during the windshield survey and general information for each structure is summarized in Table 2.1.

In addition to data collected during the windshield survey, farm structure data was determined from CAD files provided by Collier Enterprises. The location of the Collier Enterprises structure data contained in the CAD files are shown in Figure 2.2. Table 2.2 summarizes the structure types and whether the invert elevations of the Collier Enterprises structure data was surveyed or estimated from the topographic data with the assumption that culverts are at least 3 feet below the road surface elevation.

The locations of structures in the Ave Maria area were identified in the New Town Development of Regional Impact (DRI) Application. The location of the identified structures is shown in Figure 2.3 and a description of the features is given in Table 2.3.

The locations of farm structures in other areas was estimated using aerial photographs, available topographic data, and an assumption that culverts are located at least 3 feet below the road surface elevation determined from the topographic data. The locations of the structures interpreted from the aerial photographs are shown in Figure 2.18. A summary of the photo-interpreted structures is given in Table 2.4.

2.2 METEROLOGIC, HYDROLOGIC, AND HYDRAULIC DATA

Spatially distributed rainfall and reference evapotranspiration (RET) data developed by SFWMD were collected for this study. The District used all available rainfall and RET observation gages and a Triangular Irregular Network (TIN) interpolation method to interpolate gage data on a 2-mile square grid network that covers most of the District. The rainfall and RET data was used previously in the Picayune Strand Restoration Project model (PSRP). Spatially distributed rainfall data for the 5-day 10-year, 5-day 25-year, and 5-day 100-year design events were also collected for this study. The design event rainfall data were developed using District design storms and storm-event recurrence isohyetal maps developed by the District (Pathak, 2001) and were also used previously in the PSRP model (DHI, 2004; SFWMD, 2004).

The period of interest (POI) for the Camp Keais Strand Flowway project was based on the calibration/validation period of the PSRP model. The calibration/validation period for the PSRP model ranged from January 1994 through December 1999 and are summarized in Table 2.5. For the purposes of this study the calibration period is 1995 to 1999.

Stream stage and groundwater level data for seven (7) surface water and seven (7) groundwater observation gages near Camp Keais Strand were retrieved from the SFWMD DBHYDRO online database. The ID and period of record within the POI for the observation data are summarized in Table 2.5. The vertical datum of the observation data retrieved from DBHYDRO was adjusted from NGVD 1929 to NAVD 1988 to be consistent with the elevation data used in the PSRP PIR model. The observed data for the calibration/validation period is shown in Figure 2.5 to Figure 2.17.

All hydraulic and hydrologic data utilized in this study was derived from the PSRP PIR model with the exception of structure elements discussed previously and cross-section data for the Camp Keais Strand area and Fakahatchee Strand north of I-75. High resolution topographic data was available for the Immokalee and Camp Keais Strand Area. The high resolution data was developed using photogrammetric methods and had a 5 ft resolution in the Immokalee area and a 10 ft resolution in the Camp Keais area. The extent of the photogrammetric data is shown in Figure 2.19. Topographic data was also available from the recent US Army Corps of Engineers (USACE) survey of Lake Trafford and a composite digital elevation model (DEM) of Southwest Florida developed by SFWMD.

All of these topographic data sources were relied upon to extract cross-sections for the Camp Keais Strand area, cross-sections for the Immokalee area, and develop a comprehensive DEM for the study area. Cross-sections were extracted using the highest resolution data available for an area to reduce spatial averaging. A representation of the comprehensive DEM with a 100 ft horizontal resolution for the study area using the best available data for each location is shown in Figure 2.20. The locations of cross-sections extracted from the DEM data are also shown in Figure 2.20. A total of 541 cross-sections were extracted from the DEM. The extracted cross-section data was augmented using the aerial photographs to limit the horizontal extent of the cross-sections to the defined extent of flowways and with available structure and/or road crossing data.

2.3 VEGETATION SURVEY

A comprehensive vegetation survey was not completed as part of this study. An analysis of the 1995 land-use coverage developed by the district was performed. The available Florida Land Use, Land Cover Classification System (FLUCCS) data was further classified into 22 broader classes which are summarized in Table 2.6. The predominant land-use types in the Camp Keais Strand and surrounding vicinity is hydric flatwood (22.0%), cypress (22.2%), truck crops (12.8%), and citrus (5.8%). The spatial distribution of the 22 defined classes is shown in Figure 2.21.

2.4 DRAINAGE BASIN DELINEATION

The major sub-basins in the Camp Keais Strand area are shown in Figure 2.22. These sub-basins were delineated by SFWMD staff and were considered sufficient for this project because the evaluation of existing conditions and alternatives analysis will be performed using the MIKE SHE / MIKE 11 software package. It is not necessary to define surface water sub-basins in MIK SHE / MIKE 11 because it uses a spatially varying topography dataset to determine overland flow directions and runoff routing.

2.5 FLOWWAY EVALUATION

A combination of the windshield survey and analysis of the available aerial photography was used to develop the map of disturbed and undisturbed flow ways shown in Figure 2.23. In general, the flow ways for Camp Keais Strand and Fakahatchee Strand have been modified by agricultural activities. In general, disturbed areas correspond to areas that are classified as citrus and truck crop land-use types in Figure 2.21. Other areas of disturbed flow ways in the area of interest include developed areas in Golden Gate Estates in the vicinity of Faka Union Canal, Merritt Canal south of I-75, Prarie Canal, Fakahatchee Strand south of I-75, and along I-75 in the vicinity of the north and south barrow canals.

3.0 EVALUATION OF EXISTING CONDITIONS (TASK 2)

The objective of Task 2 was to apply a reasonable and appropriate hydrologic and hydraulic simulation methodology in order to develop a well calibrated model to simulate existing conditions in the Camp Keais Strand area. The PSRP PIR MIKE SHE / MIKE 11 model was used as the starting point for the modeling done in this project. The following sections detail the modifications made to the PSRP PIR model to meet the objectives of this project, an assessment of the calibration of the revised model, and an assessment of the existing conveyance capacity of the strand to identify problems and wetland functions.

3.1 MODIFICATIONS TO THE PSRP PIR MODEL

In general, the PSRP PIR model was modified to better represent the hydrology and hydrography in the Camp Keais Strand area. Furthermore, because the focus of this modeling effort is on assessment of conditions in the Camp Keasis Strand area a submodel (CKS) was developed from the PSRP PIR model for the defined area of interest. The area of interest was defined by the sub-basins defined by SFWMD that contain Camp Keais Strand or that contribute flow to Camp Keais Strand. The sub-basins included the Faka Union Canal sub-basin, the Fakahatchee Strand sub-basin, and portions of the Cocohatchee subbasin. The area of interest is comprised of the contributing areas from Lake Trafford to the control structures on Faka Union Canal (FU-2), Merritt Canal (Merritt-1), Prairie Canal (Prairie-1), and portions of Fakahatchee Strand south of I-75.

The CKS model developed for the Camp Keais area was further refined to use a 500 ft horizontal discretization rather than the 1,500 ft grid cell size used in the PIR model. The smaller cell size used for the CKS model in combination with the revised topography allows for better resolution of overland flow processes than was possible with the PSRP PIR model. The following paragraphs summarize the changes made to the MIKE 11 and MIKE SHE datasets in the CKS model. In order to maintain consistency with previous PIR modeling efforts the changes we kept to those essential for this project.

3.1.1 MIKE 11 Modifications

In the PSRP PIR model, the hydrography of Camp Keais Strand and Fakahatchee Strand north of I-75 was very general as shown in Figure 3.1. The hydrography was revised based on the windshield survey, the aerial photography analysis, data provided by Collier Enterprises, and data summarized in the Ave Maria DIR; the revised hydrography used in the CKS model is shown in Figure 3.2. As shown in Figure 3.2, the revised hydrography is a much better representation of the hydrography for the area and as will be shown in the calibration section the CKS model does a good job of simulating conditions in the area of interest that was not included in the PSRP PIR.

A total of 693 cross-sections were used in the CKS MIKE 11 model (Figure 3.3). As indicated previously, 541 cross-sections were derived from the highest resolution topographic data available for an area. The remaining 152 cross-sections were from the PSRP PIR model.
The control structures simulated in the CKS model are shown in Figure 3.4. Details for each control structure are given in Table 3.1. A total of 9 control structures were simulated in the

CKS model and includes one additional control structure location in the Collier Enterprises area south of CR-858.

A total of 7 bridges were explicitly modeled in the CKS model and their locations are shown in Figure 3.5. The data sources and additional detail for the bridges are summarized in Table 3.2. Data for the two bridges on Camp Keais Strand at CR 846 and CR 858 were derived from the engineering plans for bridges provided by SFWMD staff. The remaining five additional bridges in the CKS model were derived from the UNET model developed for the area (Dames & Moore, 1998).

A total of 34 culverts were modeled in the CKS model and are shown in Figure 3.6. Thirty-one of the 34 culverts were added as part of this study using data made available by Collier Enterprises, contained in the Ave Maria DIR, or estimated from a combination of aerial photography and the topographic data available for the area. Details of the culverts included in the CKS model are summarized in Table 3.3.

A total of 57 weirs were modeled in the CKS model and are shown in Figure 3.7. Forty of the 57 weirs were added as part of this study using data estimated from a combination of aerial photography and the topographic data available for the area. Details of the weirs included in the CKS model are summarized in Table 3.4. As indicated in Table 3.4, most of the weirs represent road crossings.

Stage boundary conditions were specified for all branches that are physically connected to canals not simulated in the CKS MIKE 11 model but simulated in the PSRP PIR model. The branches that used stage boundary conditions included Faka Union Canal (33,889), Merritt Canal (11,802), Prairie Canal (8,834), Fakahatchee Strand (26,050), ImmokaleeS (0), ImmS10809R (5690), CorkscrewSE (0). All other branches were connected to interior branches or used zero flux boundaries at free branch ends. The head and zero flux boundary conditions specified in the MIKE 11 model are shown in Figure 3.8. In addition to hydrodynamic boundary conditions, an evaporation boundary condition was applied to Lake Trafford to simulate evaporation from the water surface. The evaporation boundary condition was specified as the difference in pan evaporation rates at the BCB field station and the reference evapotranspiration used in MIKE SHE and was applied to account for higher evaporation rates from Lake Trafford. The evaporation rate applied in MIKE 11 ranges from 0.00 to 1.13 inches per day over the simulation period with an average of 0.014 inches per day.

3.1.2 MIKE SHE Modifications

In general, the PSRP PIR model was used to develop the CKS model. Because the cell size of the CKS model was reduced from 1,500 ft to 500 ft the original datasets used to develop the PIR model were used to develop datasets for the CKS model. The reader is referred to the PSRP PIR reports (DHI, 2004; SFWMD, 2004) for information related to development of datasets not discussed further below.

The only significant changes made to the MIKE SHE setup were changes to the drainage and separated overland flow data sets. The existing drainage datasets were modified in order to better represent the agricultural areas in the Camp Keais Strand area. The locations of the

drainage areas and separated overland flow areas corresponding to the agricultural areas are shown in Figure 3.9. The drainage and separated overland flow areas developed in the CKS model were merged with the base datasets from the PSRP PIR model.

The drainage depths in the agricultural areas were set to 1.5 and 3 ft below land surface for truck crop and citrus land-use classifications, respectively. These modified drainage depths were based on information provided by Collier Enterprises. The land-use based drainage time constant associations from the PSRP PIR model were used in the CKS model. Drainage water from the farm areas was routed to the closest MIKE 11 branch or to specified branches adjacent to farm fields with data made available by Collier Enterprises. Separated overland flow areas were specified for all active farm fields because levees and/or farm roads separate the farm fields from surrounding areas and farmers manage water in their fields through use of farm pumps and a network of interior drainage canals.

The setup of the hydrostratigraphy and groundwater parameters in the CKS model is identical to the PSRP PIR model. Simulated long-term groundwater results were extracted from the PSRP PIR model and used as time-varying boundary conditions for the outer boundary of the CKS model.

3.2 CALIBRATION OF THE CKS MODEL

The calibration period for the CKS model was defined 1995 to 1999 which is the same as the PSRP PIR model. Although the entire calibration period was considered, the focus of calibration activities was calibration of the model to simulate conditions during the wet season. The wet season focus was used because all of the scenarios were evaluated with the PSRP PIR design events (i.e., long-term response of the system to the proposed scenarios was not evaluated). Furthermore, calibration activities were further focused on improving the surface water calibration in Camp Keais Strand. No additional calibration of the groundwater component was performed in this project.

3.2.1 Model calibration statistics

The surface water and groundwater calibration statistics for 1995 to 1999 are summarized in Table 3.5 and Table 3.6. Comparisons of simulated and observed surface water results at Faka Union Number 4 Headwater, Camp Keais Strand at CR-846, Camp Keais Strand at CR-858, Lake Trafford, Lucky Lake Headwater, and Lucky Lake Tailwater are shown in Figure 3.10 to Figure 3.15. No calibration data was available at the Merritt Canal near I-75 gage in the calibration period. In general, the surface water calibration is very good, particularly at high stages, with mean stage errors less than 1 ft, except at Faka Union Number 4. The mean error at Faka Union Number 4 is slightly larger than in the PSRP PIR (-0.916 ft for the PSRP PIR vs. -1.06 ft for the CKS) but the correlation coefficient is slightly better (0.698 for the PSRP PIR vs. 0.72 for the CKS). Since the Faka Union Canal is at the boundary of the area of interest, the differences in simulated results between the PSRP PIR and this study should not be significant.

Comparisons of simulated and observed groundwater results are shown in Figure 3.16 to Figure 3.21. Mean errors are less than 1 ft at all groundwater wells in the domain except for C-531, C-988, and C-1079. Well C-531 is located very close to the model boundary so the relatively poor

statistics at this location reflect inaccuracies in the boundary conditions used relative to the revised topography. Similar to the surface water statistics, simulated and observed responses correlate very well at high groundwater levels and indicate the model calibration is appropriate for use with design storm simulations.

3.2.2 Summary of Model Calibration

In general, the model performs very well during wet season conditions and is appropriate for use in this project. However, the model tends to perform poorer during dry season conditions. The performance of the PSRP PIR model was similar to the CKS model during the dry season.

Poor performance during the dry season may reflect the need to reevaluate dry season evapotranspiration parameters and how agricultural pumpage is distributed in the model. Currently, most agricultural pumpage is simulated as shallow wells rather than using individual wells. Shallow wells tend to reduce simulated drawdown and can be significant if calibration wells, such as C-1079, are located close to agricultural withdrawals. It is suggested that additional evaluation of evapotranspiration parameters and irrigation uses be conducted in subsequent investigations, particularly if the model is going to be used to simulate long-term or dry season conditions.

3.3 ASSESSMENT OF THE EXISTING CONVEYANCE

To assess the existing conveyance in the system the calibrated model was run using the 5-day 100-year design event (Figure 3.22). The maximum water depth during the 5-day 100-year design event was used rather than the maximum water depth for the calibration period because the design event uses hourly intensities and the intensity and depths applied in the design event exceed the largest event in the calibration period. As such, the 5-day 100-year design event should be sufficient for identifying areas where restrictions in system conveyance are present.

Based on analysis of the 5-day 100-year design storm simulation it appears the existing conveyance is restricted at the following locations.

1. North of the bridge on CR-846 in the East Corkscrew area (Shaggy Cypress area).
2. South of CR-846 in between the agricultural areas on the east side of Camp Keais Strand
3. North of CR-858 just upstream of the single barrel culvert in the main Camp Keais Strand flowway. The culvert is the restriction to flow at this location.
4. South of CR-858 on the western side of Camp Keais Strand
5. South of CR-858 on the eastern side of Camp Keais Strand just north of the Collier Enterprises control structure (culvert with wooden flashboards) in the main flowway
6. North of the constriction on the west side of Camp Keais Strand within Collier Enterprises farm areas before the connection with Stumpy Strand (southwest side of the area defined as Camp Keais Strand)

These areas correspond to areas defined as disturbed flowways in Figure 2.23. These areas are also areas that are addressed as part of the scenarios described in the following section.

4.0 DEVELOPMENT AND ANALYSIS OF ALTERNATIVES (TASK 3)

The objective of Task 3 was to develop, in collaboration with District staff, an array of alternatives to achieve the desired conveyance and wetland function of the flowway. Feasible alternatives were simulated using the hydrologic-hydraulic model developed in Task 2. The following sections detail the components of each scenario, and the simulated hydrologic response of the modified system to the 5-day 10-year, 5-day 25-year, and 5-day 100-year design events developed for the PSRP PIR model at select locations in the model. The locations where scenario results are evaluated are shown in Figure 4.1. At locations 5 and 6, scenario discharge and stages are evaluated at location 6 and at the headwater end of location 5 and the tailwater end of location 6, respectively; these evaluation locations were used because modifications at location 5 and 6 are intended to increase discharge to southern portions of Camp Keais Strand and decrease water retention north of location 5. An overall assessment of the performance of each alternative is given after discussion of the specific response of the system to the modifications made in each scenario.

4.1 SCENARIO COMPONENTS

A total of three scenarios were developed for the CKS model. For each scenario, an initialization simulation (January 1, 1994 to August 1, 1995) was run to develop reasonable initial conditions for the design events. Three (3) design events were run for each scenario. The design events included a 5-day 10-year, 5-day 25-year, and 5-day 100-year design storm and are identical (in intensity and spatially) to the design events used in the PSRP PIR model.

The three scenarios included the following components. Geometric data for the existing structures on CR-858 that are modified as part of Scenario 1 to 3 are summarized in Table 4.1.

4.1.1 Scenario 1 – Modification of Hydraulic Components 1

a. Replace the existing culvert on CR 858 at the main flow-way of Camp Keais Strand with a bridge based on the bridge design developed by CH2MHill as part of the CR 858 road redesign. This bridge will be approximately 1,000 ft east of the exisiting culvert and include a panther crossing under the bridge deck. The elevation of the pather crossing was based on the average simulated water level from the calibrated model (16.75 ft NAVD). Since the new Camp Keais Strand bridge will span a natural flow-way rather than a dug canal the dimensions were not optimized to achieve a simulated head loss less than 0.1 feet through the bridge. The new bridge is designed to have 4 feet of freeboard above the design high water elevation (DHW) for the low member of the bridge for the 100-year design storm. The geometric data for this modified structure is shown in Figure 4.2 and summarized in Table 4.2.

b. The existing Camp Keais Strand bridge on CR 858 will be converted to two 6 ft high x 12 ft wide x 100 ft long culverts. The culvert invert elevations were formulated to be similar to the canal low point elevation of the current bridge and is sufficient to reduce the head loss through the structure to less than 0.1 ft. The geometric data for this modified structure is summarized in Table 4.2.

c. The existing Faka Union Canal bridge at CR 858 was modified for conveyance in order to achieve a head loss through the bridge of less than 0.1 feet for the 100-year design storm and to obtain at least a 4 ft freeboard above the low member from the DHW. The geometric data for this modified structure is shown in Figure 4.3 and summarized in Table 4.2.

4.1.2 Scenario 2 – Modification of Hydraulic Components 2

a. All components from Scenario 1.

b. Degrade 500 ft of the old rail road grade located approximately 200 ft south of CR 858 to natural ground elevation.

c. Removal of 100 ft of farm road at the location of the three (3) Collier Enterprises flashboard weir structures within Camp Keais Strand south of CR 858. This modification was proposed by Collier Enterprises and will reduce the obstruction to flow within Camp Keais Strand. The existing flash board weir structures will remain but be left in an open position.

d. Replace the existing bridge on CR 846 at Camp Keais Strand with a bridge identical to the new bridge on CR 858 at Camp Keais Strand. The vertical elevation of the bridge design for CR 858 has been adjusted to be consistent with the elevation at the current bridge location. The geometric data for this bridge is shown in Figure 4.4 and summarized in Table 4.2.

e. Replace the Barron-Collier farm culverts under two farm roads that cross the main Camp Keais Strand flowway at the southern end of Camp Keais Strand. The geometry data for these structures is approximate and the two existing 4 ft diameter circular culverts are replaced by 4 ft diameter circular culverts. The geometric data for these culverts are summarized in Table 4.2.

4.1.3 Scenario 3 – Future Conditions

a. All components from Scenarios 1 and 2.

b. The flow-way, habitat and water retention elements of the Collier County Rural Land Stewardship land cover complex map for the flow-way enhancement features were used to define storage elements in the future conditions model. The relationship of land-use and Mannings M roughness coefficients, vegetation properties, and drainage modifications for the areas defined as habitat, flowway, and water retention areas were derived from the PSRP PIR model and are consistent with the approach used for developing the calibrated CKS model. The resultant 2050 land-use map is shown in Figure 4.5.

c. Areas defined as open lands in the Collier County Rural Land Stewardship land cover complex map for Collier Enterprises property in the Camp Keais Strand area were simulated using the same land-use type (urban density), Mannings M roughness coefficients, vegetation properties, irrigation approach, and drainage modifications as used in the Ave Maria area in the PSRP PIR model. This

approach assumes that maximum build-out will occur and that will be developed to the same density simulated for the Ave Marie area in the PSRP PIR model.

4.1.4 Bridge Design Assumptions

The following assumptions were made for developing the bridge geometry data used in the scenarios:

- The modified channel geometry will maintain the same low point elevation used in the calibrated model (i.e., the channel will not be excavated deeper than the current low point elevation).
- The geometry of the new Camp Keais Strand bridge at CR 858 is based on the geometric data provided by CH2MHill.
- The geometry of the new Camp Keais Strand bridge at CR 846 is based on the geometric data provided by CH2MHill for the bridge at CR 858 and has been adjusted to reflect topographic differences between the two areas.
- The following assumptions have been used for the modified bridge on Faka Union Canal at CR 858
    - Bridge abutments for the Faka Union at CR858 will have a slope of 2:1.
    - A combination of three 40 foot and one 25 foot bridge spans will be used. The 25 foot span was used to accommodate the panther crossing.
    - Each 40 foot bridge span will have one bent with 24 inch pilings (piling/span = 0.05).
    - The span length assumes AASHTO type II or type III girders with a thickness of 3.75 feet and a 1 foot roadway deck for a total thickness of 4.75 feet from the low chord to the road surface.

The following sections summarize the results of the scenario analyses.

4.2 EXISTING CONDITIONS RESPONSE (SCENARIO 0)

The system response to the design storm events for the existing conditions model are shown in Figure 4.6 to Figure 4.20. The existing conditions model results represent the base case model for all scenario comparisons. The figures presented for Scenario 0 show simulated headwater and tailwater elevations for the 5-day 100-year design events, simulated stages for all three design events, and simulated discharges for all three design events.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing culvert on CR 858 at Camp Keais Strand (location 1 in Figure 4.1) were 20.5 and 16.4 ft NAVD (Figure 4.6), respectively, and the maximum discharge was 96.2 cfs (Figure 4.8). The high maximum head difference between the upstream and downstream ends of the existing culvert are a result of the limited conveyance capacity of the existing structure.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing bridge on CR 858 at Camp Keais Strand (location 2 in Figure 4.1) were 18.47 and 18.46 ft

NAVD (Figure 4.9), respectively, and the maximum discharge was 34.65 cfs (Figure 4.11). The discharge through the existing bridge on CR 858 at Camp Keais Strand is low relative to the size of the bridge because of the flow obstructions to the south and the limited contributing area for this bridge north of CR 858. The current bridge meets the 0.1 ft head difference criteria specified as a design constraint for bridges in channelized canals but does not meet the 4 ft freeboard criteria.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing bridge on CR 858 at Faka Union Canal (location 3 in Figure 4.1) were 14.8 and 14.7 ft NAVD (Figure 4.12), respectively, and the maximum discharge was 368.8 cfs (Figure 4.14). The current bridge meets the 0.1 ft head difference criteria specified as a design constraint for bridges in channelized canals but does not meet the 4 ft freeboard criteria.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing bridge on CR 846 at Camp Keais Strand (location 4 in Figure 4.1) were 20.6 and 20.5 ft NAVD (Figure 4.15), respectively, and the maximum discharge was 1,057 cfs (Figure 4.17). The current bridge meets the 0.1 ft head difference criteria specified as a design constraint for bridges in channelized canals but does not meet the 4 ft freeboard criteria.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing Barron-Collier farm culverts on CR 858 at Camp Keais Strand (locations 5 and 6 in Figure 4.1) were 16.0 and 12.2 ft NAVD (Figure 4.18), respectively, and the maximum discharge was 120.3 cfs (Figure 4.20). The high maximum head difference between the upstream and downstream ends of the existing culvert is a result of the limited conveyance capacity of the existing structures and the approximately one foot topographic difference between the headwater side of location 5 and the tailwater side of location 6.

4.3 SYSTEM RESPONSE IN SCENARIO 1

The system response to the design storm events for Scenario 1 is shown in Figure 4.21 to Figure 4.35. The figures presented for Scenario 1 show simulated headwater and tailwater elevations for the 5-day 100-year design events, simulated stages for all three design events, and simulated discharges for all three design events. Furthermore, a comparison of the difference in the maximum overland flow depths relative to existing conditions (Scenario 0) is shown in Figure 4.36.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing culvert on CR 858 at Camp Keais Strand (location 1 in Figure 4.1) were 19.1 and 18.9 ft NAVD (Figure 4.21), respectively, and the maximum discharge was 1,607 cfs (Figure 4.23). The new bridge on CR 858 at Camp Keais Strand allows approximately 1,510 cfs of additional water to flow across CR 858 and a 1.4 ft reduction in the maximum head difference between the upstream and downstream sides of the bridge at this location relative to existing conditions. The proposed new bridge on CR 858 at Camp Keais Strand represents a significant improvement in conveyance and meets the 4 ft freeboard criteria specified for the bridge.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed culvert on CR 858 at Camp Keais Strand (location 2 in Figure 4.1) were 18.9 and 18.9 ft NAVD

(Figure 4.24), respectively, and the maximum discharge was 37.7 cfs (Figure 4.26). The discharge through the proposed culverts still remains low at this location because of the flow obstructions to the south and the limited contributing area for this bridge north of CR 858. The proposed culverts increase stages by 0.4 ft but are adequate for their intended purpose; increased stages at this location is a result of the reduced conveyance of the culverts relative to the existing bridge.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed modified bridge on CR 858 at Faka Union Canal (location 3 in Figure 4.1) were 14.93 and 14.90 ft NAVD (Figure 4.27), respectively, and the maximum discharge was 289.1 cfs (Figure 4.29). The proposed modified bridge meets the 0.1 ft head difference criteria specified as a design constraint for bridges in channelized canals and meets the 4 ft freeboard criteria.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing bridge on CR 846 at Camp Keais Strand (location 4 in Figure 4.1) were 20.3 and 20.0 ft NAVD (Figure 4.30), respectively, and the maximum discharge was 1,831 cfs (Figure 4.32). Although the geometry of the bridge has not been modified improvements to features crossing CR 858 to the south have resulted in lower stages and increased flow at the bridge on CR 846 at Camp Keais Strand.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing Barron-Collier farm culverts on CR 858 at Camp Keais Strand (locations 5 and 6 in Figure 4.1) were 18.5 and 12.2 ft NAVD (Figure 4.33), respectively, and the maximum discharge was 147.3 cfs (Figure 4.35). The increased maximum stage at location 5 and discharge at location 6 is a result of improvements to the features crossing CR 858 at Camp Keais Strand and increased flow north of location 5.

The comparison of the maximum overland flow depths relative to existing conditions for the 5-day 100-year design event (Figure 4.36) shows that the new bridge is effective at decreasing overland depths north of CR 858 and increasing overland depths south of CR 858 in the main Camp Keais Strand flowway. The proposed changes to the structures on Camp Keais Strand also causes a slight reduction in overland flow depths in the Shaggy Cypress area, Collier Enterprises farm areas south of Shaggy Cypress, and south of the Barron-Collier farm structures in Camp Keais Strand. Maximum increases in overland depths south of CR 858 in Camp Keais Strand are concentrated north of the southern most Barron-Collier farm culvert crossing Camp Keais Strand (location 6 in Figure 4.1).

4.4 SYSTEM RESPONSE IN SCENARIO 2

The system response to the design storm events for Scenario 2 is shown in Figure 4.37 to Figure 4.51. The figures presented for Scenario 2 show simulated headwater and tailwater elevations for the 5-day 100-year design events, simulated stages for all three design events, and simulated discharges for all three design events. Furthermore, a comparison of the difference in the maximum overland flow depths relative to existing conditions (Scenario 0) is shown in Figure 4.52.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing culvert on CR 858 at Camp Keais Strand (location 1 in Figure 4.1) were 19.4 and 19.2 ft NAVD (Figure 4.37), respectively, and the maximum discharge was 2,189 cfs (Figure 4.39). The new bridge on CR 846 at Camp Keais Strand and degradation of the old railroad grade south of CR 858 allows approximately 680 cfs of additional water to flow across CR 858 and approximately a 0.3 ft reduction in the stages relative to Scenario 1. The proposed conveyance modifications at CR 846 and south of CR 858 in the Camp Keais Strand flowway represent a significant improvement.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed culvert on CR 858 at Camp Keais Strand (location 2 in Figure 4.1) were 19.18 and 19.19 ft NAVD (Figure 4.40), respectively, and the maximum discharge was 44.2 cfs (Figure 4.42). The discharge through the proposed culverts is nearly the same in Scenario 2 as it was in Scenario 1 and maximum simulated stages are approximately 0.5 ft higher.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed modified bridge on CR 858 at Faka Union Canal (location 3 in Figure 4.1) were 14.95 and 14.93 ft NAVD (Figure 4.43), respectively, and the maximum discharge was 288.4 cfs (Figure 4.45). Simulated stages and discharge in Scenario 2 are approximately the same as Scenario 1 on CR 858 at Faka Union Canal.

The maximum upstream and downstream stages during the 5-day 100-year event at the modified bridge on CR 846 at Camp Keais Strand (location 4 in Figure 4.1) were 20.4 and 20.1 ft NAVD (Figure 4.46), respectively, and the maximum discharge was 2,469 cfs (Figure 4.48). The proposed modifications to the bridge geometry have increased the flow in Camp Keais Strand by approximately 640 cfs but do not modify the stage significantly. The proposed modifications represent a significant improvement to flow in Camp Keais Strand south of CR 858.

The maximum upstream and downstream stages during the 5-day 100-year event at the modified Barron-Collier farm culverts on CR 858 at Camp Keais Strand (locations 5 and 6 in Figure 4.1) were 19.0 and 12.3 ft NAVD (Figure 4.49), respectively, and the maximum discharge was 362.0 cfs (Figure 4.51). The proposed modifications to the Barron-Collier structures in combination with the changes to the bridge at CR 846 on Camp Keais Strand and degradation of the rail road grade south of CR 846 increases the flow entering the southern portions of Camp Keais Strand by a factor of 2.5 and represent a significant improvement.
The comparison of the maximum overland flow depths relative to existing conditions for the 5-day 100-year design event (Figure 4.52) shows the cumulative effect of the proposed Scenario 1 and Scenario 2 changes. Cumulatively, the changes on Camp Keais Strand permit increased overland depths throughout the main flowway.

4.5 SYSTEM RESPONSE IN SCENARIO 3

The system response to the design storm events for Scenario 3 is shown in Figure 4.53 to Figure 4.67. The figures presented for Scenario 3 show simulated headwater and tailwater elevations for the 5-day 100-year design events, simulated stages for all three design events, and simulated discharges for all three design events. Furthermore, a comparison of the difference in the

maximum overland flow depths relative to existing conditions (Scenario 0) is shown in Figure 4.68.

The maximum upstream and downstream stages during the 5-day 100-year event at the existing culvert on CR 858 at Camp Keais Strand (location 1 in Figure 4.1) were 19.36 and 19.31 ft NAVD (Figure 4.53), respectively, and the maximum discharge was 2,201 cfs (Figure 4.55). Simulated flows through the new bridge on CR 858 at Camp Keais Strand are approximately 10 cfs greater than simulated in Scenario 2.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed culvert on CR 858 at Camp Keais Strand (location 2 in Figure 4.1) were 19.18 and 19.19 ft NAVD (Figure 4.56), respectively, and the maximum discharge was 43.67 cfs (Figure 4.58). The simulated stage and discharge through the proposed culverts is nearly the same in Scenario 3 as Scenario 2.

The maximum upstream and downstream stages during the 5-day 100-year event at the proposed modified bridge on CR 858 at Faka Union Canal (location 3 in Figure 4.1) were 14.72 and 14.69 ft NAVD (Figure 4.59), respectively, and the maximum discharge was 399.5 cfs (Figure 4.61). The stages are slightly reduced in Scenario 3 relative to Scenario 2 (~0.2 ft). Simulated discharge in Scenario 3 at the bridge on CR 858 at Faka Union Canal is approximately 100 cfs higher that Scenario 2 and reflects increased runoff resulting from urbanization.

The maximum upstream and downstream stages during the 5-day 100-year event at the modified bridge on CR 846 at Camp Keais Strand (location 4 in Figure 4.1) were 20.4 and 20.4 ft NAVD (Figure 4.62), respectively, and the maximum discharge was 2,466 cfs (Figure 4.64). There is no significant difference between Scenario 2 and 3 simulated stages and discharges at the modified bridge on CR 846 at Camp Keais Strand.

The maximum upstream and downstream stages during the 5-day 100-year event at the modified Barron-Collier farm culverts on CR 858 at Camp Keais Strand (locations 5 and 6 in Figure 4.1) were 19.0 and 12.2 ft NAVD (Figure 4.65), respectively, and the maximum discharge was 360.7 cfs (Figure 4.67). There is no significant difference between Scenario 2 and 3 simulated stages and discharges at the modified Barron-Collier farm structures.
The comparison of the maximum overland flow depths relative to existing conditions for the 5-day 100-year design event (Figure 4.68) shows the cumulative effect of the proposed Scenario 1 and Scenario 2 changes combined with the land-use and associated parameter changes implemented in Scenario 3. Cumulatively, the Scenario 1 and Scenario 2 changes combined with 2050 land-use changes are result in similar maximum overland flow depth changes in the Camp Keais Strand area. Land-use changes, however, increase maximum overland flow depths in Golden Gate Estates and lands that were agricultural lands in 1995.

4.6 SUMMARY OF SCENARIO RESULTS

The proposed modification to the structures on CR 858 at Camp Keais Strand, Faka Union Canal, and CR 846 at Camp Keais Strand meet the design criteria established during the project. The proposed new bridge on CR 858 Camp Keais Strand represents the most significant component of improvement to the flowway and increases the magnitude of discharge crossing

CR 858 at Camp Keais Strand (~1,415 cfs). Improvement of the bridge on CR 846 at Camp Keais Strand and degradation of the old rail road grade south of CR 858 also represents a significant improvement to the magnitude of discharge crossing CR 858 (~680 cfs).

Improvements to the Barron-Collier farm structures increases discharge through the main Camp Keais Strand flowway by a factor of 2.5 but these features represent a major restriction in the system under high-flow conditions. It should be noted that the dimensions and invert elevations of the Barron-Collier structures have been estimated using available topographic data and best engineering judgment; as a result, there is some uncertainty associated with simulated results in this area. Further improvements to the conveyance capacity of the Barron-Collier structures would further increase discharge to southern portions of Camp Keais Strand under high flow conditions and may be something to consider in future analyses of the area.

Land-use changes simulated in Scenario 3 to represent 2050 future conditions do not appear to significantly affects the results within in Camp Keais Strand but they do increase maximum overland depths in Golden Gate Estates and farm lands converted to other uses outside of Camp Keais Strand.

5.0 IMPROVEMENT PLAN RECOMMENDATION

This section presents recommended conceptual layouts and structural modifications of several existing drainage facilities, including approximate dimensions and conceptual-level cost estimates, anticipated permit requirements, and proposed maintenance maintenance for the recommended facilities.

Figure 5.1 presents a layout of the recommended facilities. Descriptions of the six facilities are as follows:

1. Replace the existing culvert on CR 858 at the main flow-way of Camp Keais Strand with a bridge based on the bridge design currently being developed by CH2M HILL for the Collier County as part of the CR 858 road improvement design. This bridge will be approximately 1,000 ft east of the existing culvert and include a panther crossing under the bridge deck. The elevation of the panther crossing was based on the average simulated water level from the calibrated model (16.75 ft NAVD). The new bridge is designed to have 4 ft. of freeboard above the design high water elevation (DHW) for the low member of the bridge for the 100-year design storm.
2. Replace the existing Camp Keais Strand bridge on CR 858 to two 6-ft-high x 12-ft-wide x 110-ft-long culverts. The culvert invert elevations were formulated to be similar to the canal low point elevation of the current bridge and are sufficient to reduce the head loss through the structure to less than 0.1 ft.
3. Degrade 500 ft of the old railroad grade located approximately 200 ft south of CR 858 to natural ground elevation.
4. Replace the existing bridge on CR 846 at Camp Keais Strand with a bridge identical to the new bridge on CR 858 at Camp Keais Strand. The vertical elevation of the bridge design for CR 858 has been adjusted to be consistent with the elevation at the current bridge location.
5. Replace the Barron-Collier farm culverts under two farm roads that cross the main Camp Keais Strand flowway at the southern end of Camp Keais Strand. The two existing 4-ft-diameter circular culverts on each of the farm roads are to be replaced by four 4-ft-diameter circular culverts, or by a combination of 24”, 30”, and 36” diameter circular culverts that allows the conveyance of the total discharge of 320 cfs.

The recommended facilities and their geometric data are summarized in Table 5.1. Profile views of the proposed facilities are included in Figures 5.2 through 5.6.

CH2MHILL has been contracted by Collier County to design a new bridge over Camp Keais Strand as part of the CR 858 road improvement project. While the bridge geometry presented here is based on their preliminary work, those dimensions should be considered preliminary because CH2MHILL is developing a more detailed design and cost for the CR 858 Bridge.
In addition to the structural modifications recommended above, the restoration of the historic flowways and wetland functions will also require control of exotic vegetation encroachment. The

SFWMD and cooperating agencies like the Collier Soil and Water Conservation District have been performing exotic vegetation control periodically. An evaluation of the effects of this exotic vegetation control was beyond the scope of this study. However, the continuation of existing exotic vegetation control program is recommended.

Permit Requirements

The purpose of the Camp Keais Strand Flowway project is to develop an action plan for the restoration of the natural flow regime within the Camp Keais Strand area to ensure flood peak attenuation, water quality improvements, and core wetland ecosystem function enhancement for the strand stretching between Lake Trafford and the Florida Panther National Wildlife Refugee (NWR). The project will involve modifications to existing hydrologic-hydraulic patterns and is likely to include wetland impacts. While it is believed that the benefits to the overall ecosystem will offset any direct wetland impacts due to the proposed construction, agency approvals for the project are still required. Permits that need to be obtained for implementation of this project include:

- South Florida Water Management District (SFWMD) Environmental Resource Permit (ERP)
- U.S Army Corps of Engineers (USACE) Section 404 permit
- Local Collier County permits.

USACE will solicit comments from the U.S. Fish and Wildlife Service (FWS) as part of the Section 404 permitting process. This will be of particular importance given the proximity of the project to the Florida Panther NWR. Considering the importance of this project to the protection of panther habitat, it is recommended that the FWS be contacted directly to gain concurrence with the project and to facilitate the Section 404 permit approval process.

Conceptual Cost Estimates

Table 5.2 presents a summary of the conceptual level cost estimates for the proposed facilities. Information sources used to develop the estimates included Means *Heavy Construction Cost Data – 2006* and FDOT bridge cost data. It should be noted that CH2MHILL will be developing a detailed cost estimate for the proposed CR 858 Bridge. The proposed CR 846 bridge should also use the CR 858 detailed cost estimate when available.

Appendix A of this report contains detailed descriptions of how the cost estimates for each proposed facility were determined and the spreadsheets used to calculate the estimated costs.

Land Acquisition Requirement

Additional land acquisition is required to implement the proposed projects. The new bridges, which will require a 200-ft easement based on the current design concept, would be constructed using the existing 90-ft road easements plus an additional 100-ft of easement. The additional area required for each bridge is estimated to be 0.25-0.50 acres. The detailed bridge design currently under development for Collier County will more formally determine land acquisition requirements. Regrading of the old railroad grade will require coordination with Collier Land Holdings, Ltd. with respect to acquiring access rights to perform the required construction. Replacement of the culverts on the Barron-Collier and Collier Enterprises farm roads would be performed within the existing road alignments and would be coordinated with the two organizations.

Maintenance Requirements

Routine inspections of the proposed facilities should be performed to ensure that design flow capacities are maintained. Excess vegetation and silt should be removed from culvert openings as needed. Washouts around culvert installations should be repaired to prevent sedimentation around the culverts and to maintain structural integrity of the installations.

6.0 REFERENCES

Dames & Moore, 1998. Big Cypress Basin Watershed Plan. Task D – Model Development. Prepared for SFWMD (Contract C-10738).

DHI, 2004. Big Cypress Basin Integrated Surface/Ground Water Model Development and Calibration Report. Prepared for SFWMD.

Pathak, C.S., 2001. Frequency analysis of daily rainfall maxima for Central and South Florida, South Florida Water Management District Technical Publication EMA #390, 63 p.

South Florida Water Management District, 2004. Southern Golden Gate Estates Hydrologic Restoration Final Southern Golden Gate Estates Hydrologic Restoration Integrated Project Implementation Report (PIR)/ Environmental Impact Statement (EIS). URL: http://www.evergladesplan.org/pm/projects/docs_30_sgge_pir_final.cfm., November 2004.

Wilson Miller, 2004. The Town of Ave Maria: Development pf Regional Impact Application for Development Approval Under Section 380.06, Florida Statutes.

TABLES

Table 2.1
Structures Identified During the Windshield Survey of the Camp Keais Strand Area

Name	Number of Barrels	Structure Number	X[1] (ft)	Y[1] (ft)	Notes
CR 846 B1	NA	1	497507.59	739245.97	Bridge
CR 846 C0	2	2	485381.44	739296.23	
CR 846 C1	2-3	3	490547.86	739284.44	Culvert submerged
CR 846 C2	1	4	499449.30	739237.75	
CR 846 C3	2	5	504442.40	739234.67	
CR 846 C4	3	6	510555.14	739464.69	
CR 858 B1	NA	7	499101.02	712814.29	Bridge
CR 858 C0	2-3	8	482632.63	712725.40	Culvert submerged
CR 858 C1	2	9	495154.74	712779.83	
CR 858 C1	2	10	494461.86	712776.94	
CR 858 C2	1	11	500789.55	712813.94	
CR 858 C3	2-3	12	504655.98	712838.43	Culvert submerged
CR 858 C4	1-2	13	508983.88	712920.79	Culvert submerged
CR 858 C4	1	14	508842.84	712917.23	
CR 858 C5	2-3	15	510247.67	712937.14	Culvert submerged
CR 858 C6	1	16	517152.67	713070.28	
CR 858 C7	1	17	519116.54	713104.44	
CR 858 C8	1	18	522949.69	713151.18	
CR 858 FS1	NA	19	520053.13	713241.08	Farm Structure
I75 UP	NA	20	502919.83	661724.55	Bridge
I75 UP	NA	21	502900.30	661807.21	Bridge
MRT I75 B	NA	22	495193.83	661730.12	Bridge

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)
NA - Not Applicable

Table 2.2
Structure Data Provided by Collier Enterprises

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Notes
9	CECK_C1wRiser_est	Control Structure	153370.47	215202.58	Farm Structure, estimated inverts
4	CR846_C1_svy	Culvert	149508.88	225326.52	Farm Culvert, surveyed inverts
8	CR858_C1_svy	Culvert	150920.00	217219.99	Farm Culvert, surveyed inverts
17	CR858_C2_svy	Culvert	150920.00	217219.99	Farm Culvert, surveyed inverts
18	CR858_B1_2_svy	Culvert	150920.00	217219.99	Farm Culvert, surveyed inverts
19	CECKR4_8_D18_C1and2	Culvert	149855.74	210554.20	Farm Culvert, estimated inverts
20	CECKR4_8_D21_C1to3	Culvert	149422.29	209322.78	Farm Culvert, estimated inverts
21	R7_8_C1andC2	Culvert	150809.68	218920.00	Farm Culvert, estimated inverts
24	CECKR1_C1	Culvert	150865.09	216946.39	Farm Culvert, estimated inverts
25	CECKR1_C2	Culvert	150865.09	216946.39	Farm Culvert, estimated inverts
26	CECKR4_8_C1_svy	Culvert	150832.06	215770.96	Farm Culvert, surveyed inverts
27	CECKR4_8_C2_svy	Culvert	150832.06	215770.96	Farm Culvert, surveyed inverts
28	CECKR4_8_C3_svy	Culvert	150832.06	215770.96	Farm Culvert, surveyed inverts
29	CECK_R5_C1_svy	Culvert	150769.76	214774.62	Farm Culvert, surveyed inverts
30	CECK_R5_C2_svy	Culvert	150769.76	214774.62	Farm Culvert, surveyed inverts
31	CECK_R2C1_svy	Culvert	151445.31	214295.40	Farm Culvert, surveyed inverts
32	CECK_R2C2_svy	Culvert	151445.31	214295.40	Farm Culvert, surveyed inverts
33	CECK_R5_C1_svy	Culvert	152399.96	214370.45	Farm Culvert, surveyed inverts
34	CECK_R5_C2_svy	Culvert	152399.96	214370.45	Farm Culvert, surveyed inverts
25	R7_8_Road	Weir	150809.68	218920.00	Road Crossing, estimated elevation
26	CECK_Road	Weir	153370.47	215202.58	Road Crossing, estimated elevation
27	CECK_R5_Road	Weir	151877.53	215463.39	Road Crossing, estimated elevation
28	CECK_R2_Road	Weir	151445.31	214295.40	Road Crossing, estimated elevation
29	CECK_R5_Road	Weir	152399.96	214370.45	Road Crossing, estimated elevation
30	CECK_R4_8_Road	Weir	150769.76	214774.62	Road Crossing, estimated elevation
31	CECK_R4_5_Road	Weir	152113.79	212510.00	Road Crossing, estimated elevation
40	CECKR4_8_Road	Weir	150832.06	215770.96	Road Crossing, estimated elevation
41	CECKR1_4_Road	Weir	149474.29	214800.06	Road Crossing, estimated elevation
44	CR846_Road	Weir	149508.88	225326.52	Road Crossing, estimated elevation
45	CR858_Road	Weir	150920.00	217219.99	Road Crossing, estimated elevation
46	CECKR1_R1_Road	Weir	150865.09	216946.39	Road Crossing, estimated elevation
47	CECKR1_4_C1_svy	Weir	149474.29	214800.06	Farm Weir, surveyed inverts
50	CECKR4_8_D15_Road	Weir	150133.58	210798.65	Road Crossing, estimated elevation
51	CECKR4_8_D15	Weir	150133.58	210798.65	Farm Weir, estimated inverts
52	CECKR4_8_D18_Road	Weir	149855.74	210554.20	Road Crossing, estimated elevation
54	CECKR4_8_D21_Road	Weir	149422.29	209322.78	Road Crossing, estimated elevation

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 2.3
Structures in the Ave Maria Area

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Notes
15	AM4_C2_est	Culvert	156899.30	218950.00	Farm Culvert, estimated inverts
16	AM4_C2_est	Culvert	153649.79	218789.98	Farm Culvert, estimated inverts
37	AM4_1_road	Weir	156899.30	218950.00	Farm Road, estimated elevation
38	AM4_2_berm	Weir	153649.79	218789.98	Farm Road, estimated elevation

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 2.4
Photo-Interpreted Structures in Camp Keais Strand

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Notes
11	CESC2_C2_est	Culvert	155020.59	223390.96	Farm Culvert, estimated inverts
12	CESC2_C3_est	Culvert	154680.00	222750.21	Farm Culvert, estimated inverts
13	CESC2_C4_est	Culvert	154160.85	222290.51	Farm Culvert, estimated inverts
14	CESC2_C5_est	Culvert	153490.20	221790.22	Farm Culvert, estimated inverts
33	CESC2_2_road	Weir	155020.59	223390.96	Farm Road, estimated elevation
34	CESC2_3_road	Weir	154680.00	222750.21	Farm Road, estimated elevation
35	CESC2_4_road	Weir	154160.85	222290.51	Farm Road, estimated elevation
36	CESC2_5_road	Weir	153490.20	221790.22	Farm Road, estimated elevation

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 2.5
Surface Water and Groundwater Data Available for the Area of Interest

Gage / Observation Well	Observation Type	Period of Record[1]
FakaUnion#4 Headwater	Surface Water Stage	1/1/1994 to 8/3/1994 7/22/1997 to 12/31/1999
Keais 846	Surface Water Stage	1/1/1994 to 12/31/1999
Keais 858	Surface Water Stage	1/1/1994 to 10/3/1996 3/6/1997 to 12/31/1999
Lake Trafford	Surface Water Stage	1/1/1994 to 12/31/1999
Merritt Near I-75	Surface Water Stage	1/1/1994 to 6/15/1994
Lucky Lake Headwater	Surface Water Stage	10/21/1999 to 12/31/1999
Lucky Lake Tailwater	Surface Water Stage	10/21/1999 to 12/31/1999
C-462	Groundwater level	NA[2]
C-503	Groundwater level	10/24/1996 to 12/31/1999
C-531	Groundwater level	1/1/1994 to 9/30/1996
C-598	Groundwater level	1/1/1994 to 8/29/1996
C-690	Groundwater level	2/16/1994 to 12/31/1999
C-988	Groundwater level	1/1/1994 to 12/31/1999
C-1079	Groundwater level	1/1/1994 to 9/30/1999

Notes:
1. Period of record analyzed for period of interest and gaps less than 3 months are not identified.
2. Observation data is not available in the period of interest.

Table 2.6
Land-Use Classifications in the Camp Keais Strand Area

Model Land Use Type	Camp Keais Strand Land Use Code	FLUCCS Code[1]	Area (acres)	Percentage of the Total Area (%)
Citrus	1	220[2]	16,192	8.6%
Pasture	2	210[3], 242[3]	10,958	5.8%
Sugar Cane	3	2156[4]	0	0.0%
Truck Crops	5	214[3], 215[3]	24,073	12.8%
Golf Courses	6	182[3]	0	0.0%
Bare Ground	7	160[2], 161[3], 162[3], 163[3], 182[3], 230[3], 261[3], 740[3], 742[3], 744[3], 835[3]	2,372	1.3%
Mesic Flatwood	8	190[3], 191[3], 194[3], 260[3], 310[2], 321[3], 330[2], 410[3], 411[3], 414[3], 429[3], 435[3], 440[3], 441[3], 443[3], 710[2], 720[2], 741[3]	8,591	4.6%
Mesic Hammock	9	420[3], 422[3], 423[3], 426[3], 427[3], 434[3], 437[3], 438[3], 439[3]	1,895	1.0%
Xeric Flatwood	10	412[3], 413[3]	0	0.0%
Xeric Hammock	11	322[3], 421[3], 432[3]	30	0.0%
Hydric Flatwood	12	4119[4], 419[3], 624[3]	41,225	22.0%
Hydric Hammock	13	329[3], 424[3], 425[3], 428[3], 433[3], 610[3], 611[3], 743[3]	3,491	1.9%
Wet Prarie	14	643[3], 6439[4]	6,908	3.7%
Dwarf Cypress	15	6219[4]	1,886	1.0%
Marsh	16	6171[4], 6172[4], 640[3], 641[3], 6411[4], 6412[4], 644[3]	11,401	6.1%
Cypress	17	620[3], 621[3], 6218[4], 745[3]	41,592	22.2%
Swamp Forest	18	613[3], 614[3], 615[3], 616[3], 617[3], 630[2]	10,030	5.3%
Mangrove	19	612[3], 642[3]	359	0.2%
Water	20	166[3], 500[1]	2,005	1.1%
Urban Low Density	41	110[2], 180[2], 192[3], 193[3], 240[2], 241[3], 243[3], 245[3], 246[3], 250[2]	1,442	0.8%
Urban Medium Density	42	1009[3], 120[2], 144[3], 833[3], 834[3]	1,928	1.0%
Urban High Density	43	130[2], 140[2], 150[3], 151[3], 155[3], 170[3], 810[3], 820[3], 830[3], 152[3], 153[3], 154[3], 159[3]	1,320	0.7%

Note:
[1] FLUCCS level

Table 3.1
Control Structures Simulated in the Camp Keais Strand Model.

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Branch	Chaninage	Data Source
1	FU-2-cont	Control Structure	484,361	629,990	FakaUnionCan	32,120	PIR
2	FU-3 V notch	Control Structure	484,256	660,241	FakaUnionCan	23,265	PIR
3	FU-4-cont	Control Structure	482,907	680,581	FakaUnionCan	16,954	PIR
4	FU-6 V notch	Control Structure	482,804	719,820	FakaUnionCan	5,466	PIR
5	FU-7 V notch	Control Structure	482,974	731,740	FakaUnionCan	1,976	PIR
6	Prairie-1-cont	Control Structure	505,726	625,208	PrairieCan	8,817	PIR
7	Merritt-1-cont	Control Structure	495,243	623,007	MerrittCan	11,629	PIR
9	Lucky Lake-cont	Control Structure	495,176	659,805	MerrittCan	415	PIR
10	CECK_C1wRiser_est	Control Structure	503,183	706,044	CKMain	16,135	Collier Enterprises

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 3.2
Bridges Simulated in the Camp Keais Strand Model.

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Branch	Chaninage	Data Source
1	FU_I75	Bridge	484,251	661,146	FakaUnionCan	23,000	PIR
2	CK_I75	Bridge	495,078	661,416	CKMains	11,610	PIR
3	CR846_CK	Bridge	497,473	739,125	CKMain	4,875	Bridge Design Drawings
4	CR858_CK	Bridge	499,089	712,672	CECKR1A	2,615	Bridge Design Drawings
5	FU at 56th Street Bridge	Bridge	482,927	727,645	FakaUnionCan	3,175	Dames and Moore (1998)
6	FU 43rd Avenue	Bridge	482,816	719,106	FakaUnionCan	5,675	Dames and Moore (1998)
7	FU 34th Avenue	Bridge	482,906	712,531	FakaUnionCan	7,600	Dames and Moore (1998)

Notes:
1 – NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 3.3
Culverts Simulated in the Camp Keais Strand Model

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Branch	Chainage	Data Source
1	RandallBR	Culvert	482,915	710,482	FakaUnionCan	8,200	PIR
2	34AveNE	Culvert	482,864	716,289	FakaUnionCan	6,500	PIR
3	I75-Faka	Culvert	528,608	661,702	FakaHNorth2	13,250	PIR
4	CR846_C1_svy	Culvert	490,514	739,259	CESC1	1,410	Collier Enterprises
5	CR846_4	Culvert	510,684	739,370	CESC2	4,660	Collier Enterprises
6	CR846_C2_est	Culvert	499,474	739,105	CR846Conn1	640	Collier Enterprises
7	CR846_C3_est	Culvert	504,428	739,139	CR846Conn2	560	Collier Enterprises
8	CR858_C1_svy	Culvert	495,143	712,663	CECKR7	3,065	Collier Enterprises
9	CR858_2_svy	Culvert	500,758	712,625	CKMain	13,845	Collier Enterprises
10	CESC2_1_C1_est	Culvert	512,775	738,065	CESC2	5,450	Collier Enterprises
11	CESC2_C2_est	Culvert	508,597	732,909	CESC2	8,055	Collier Enterprises
12	CESC2_C3_est	Culvert	507,479	730,806	CESC2	8,825	Collier Enterprises
13	CESC2_C4_est	Culvert	505,776	729,298	CESC2	9,565	Collier Enterprises
14	CESC2_C5_est	Culvert	503,576	727,657	CESC2	10,415	Collier Enterprises
15	AM4_C2_est	Culvert	514,760	718,338	AM4	1,620	Collier Enterprises
16	AM4_C2_est	Culvert	504,099	717,813	AM4	4,965	Collier Enterprises
17	CR858_C2_svy	Culvert	495,143	712,663	CECKR7	3,065	Collier Enterprises
18	CR858_B1_2_svy	Culvert	495,143	712,663	CECKR7	3,065	Collier Enterprises
19	CECKR4_8_D18_C1and2	Culvert	491,652	690,793	CECKR4_8	7,250	DEM
20	CECKR4_8_D21_C1to3	Culvert	490,230	686,753	CECKR4_8	8,775	DEM
21	R7_8_C1andC2	Culvert	494,781	718,240	CECKR1A	250	DEM
22	DesotoAve1	Culvert	487,337	705,826	CECKR1	3,415	DEM
23	CEFU_AtDesoto	Culvert	490,021	675,983	CEFUConn2	1,375	DEM
24	CECKR1_C1	Culvert	494,963	711,765	CECKR1	225	DEM
25	CECKR1_C2	Culvert	494,963	711,765	CECKR1	225	DEM
26	CECKR4_8_C1_svy	Culvert	494,855	707,909	CECKR4_8	685	Collier Enterprises
27	CECKR4_8_C2_svy	Culvert	494,855	707,909	CECKR4_8	685	Collier Enterprises
28	CECKR4_8_C3_svy	Culvert	494,855	707,909	CECKR4_8	685	Collier Enterprises
29	CECK_R5_C1_svy	Culvert	494,650	704,640	CECKR4_8	1,750	Collier Enterprises

Table 3.4 (continued)
Culverts Simulated in the Camp Keais Strand Model

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Branch	Chainage	Data Source
30	CECK_R5_C2_svy	Culvert	494,650	704,640	CECKR4_8	1,750	Collier Enterprises
31	CECK_R2C1_svy	Culvert	496,867	703,068	CECKR2	2,250	Collier Enterprises
32	CECK_R2C2_svy	Culvert	496,867	703,068	CECKR2	2,250	Collier Enterprises
33	CECK_R5_C1_svy	Culvert	499,999	703,314	CECKR5	2,415	Collier Enterprises
34	CECK_R5_C2_svy	Culvert	499,999	703,314	CECKR5	2,415	Collier Enterprises
35	BarronCollier-1	Culvert	502,466	692,558	CKMAINS	750	DEM
36	BarronCollier-2	Culvert	501,671	682,886	CKMAINS	4,100	DEM

Notes:

1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 3.5
Weirs Simulated in the Camp Keais Strand Model

Structure Number	Structure ID	Structure Type	X[1] (ft)	Y[1] (ft)	Branch	Chaninage	Data Source
1	link 1	Weir	492,231	764,318	IMMS10809R	1,410	DEM
2	link 1a	Weir	479,283	764,082	IMMS10809R	5,675	DEM
3	link 2b	Weir	492,963	755,850	ImmokaleeSE	11,340	DEM
4	link 2c	Weir	490,032	752,730	ImmokaleeSE	12,480	DEM
5	Block2	Weir	483,857	661,646	I75N-2	20	PIR
6	Block4	Weir	484,645	661,646	I75N-3	20	PIR
7	Block5	Weir	494,684	661,743	I75N-3	3,080	PIR
8	Block6	Weir	495,471	661,744	I75N-4	2,980	PIR
9	Block8	Weir	483,857	660,760	I75S-2	20	PIR
10	Block10	Weir	484,645	660,760	I75S-3	20	PIR
11	Block11	Weir	494,684	660,760	I75S-3	3,080	PIR
12	Block12	Weir	495,471	660,760	I75S-4	2,980	PIR
13	UpLaketrafford	Weir	499,330	759,231	ImmokaleeS	9,230	DEM
14	FU-2-weir	Weir	484,361	629,990	FakaUnionCan	32,120	PIR
15	FU-3-weir	Weir	484,256	660,241	FakaUnionCan	23,265	PIR
16	FU-4-weir	Weir	482,907	680,581	FakaUnionCan	16,954	PIR
17	FU-5-weir	Weir	482,915	707,490	FakaUnionCan	9,076	PIR
18	FU-6-weir	Weir	482,804	719,820	FakaUnionCan	5,466	PIR
19	FU-7-weir	Weir	482,974	731,740	FakaUnionCan	1,976	PIR
20	RandallWeir	Weir	482,915	710,482	FakaUnionCan	8,200	PIR
21	34AveNe	Weir	482,864	716,289	FakaUnionCan	6,500	PIR
22	RdI75Faka	Weir	528,608	661,702	FakaHNorth2	13,250	PIR
23	LinkToCKMain	Weir	496,302	754,253	LakeTrafford	3,250	DEM
24	CKR1_road	Weir	487,881	705,814	CECKR1	3,250	DEM
25	R7_8_road	Weir	494,781	718,240	CECKR1A	250	DEM
26	CECK_road	Weir	503,183	706,044	CKMain	16,135	DEM
27	CECK_R5_Road	Weir	498,285	706,899	CECKR5	1,175	DEM
28	CECK_R2_road	Weir	496,867	703,068	CECKR2	2,250	DEM
29	CECK_R5_road	Weir	499,999	703,314	CECKR5	2,415	DEM
30	CECK_R4_8_road	Weir	494,650	704,640	CECKR4_8	1,750	DEM
31	CECK_R4_5_road	Weir	499,060	697,210	CECKR4_5	1,211	DEM
32	CESC2_1_road	Weir	512,775	738,065	CESC2	5,450	DEM
33	CESC2_2_road	Weir	508,597	732,909	CESC2	8,055	DEM
34	CESC2_3_road	Weir	507,479	730,806	CESC2	8,825	DEM
35	CESC2_4_road	Weir	505,776	729,298	CESC2	9,565	DEM
36	CESC2_5_road	Weir	503,576	727,657	CESC2	10,415	DEM
37	AM4_1_road	Weir	514,760	718,338	AM4	1,620	DEM
38	AM4_2_berm	Weir	504,099	717,813	AM4	4,965	DEM
39	CECKR1A_Obstruction	Weir	499,103	712,426	CECKR1A	2,690	DEM
40	CECKR4_8_road	Weir	494,855	707,909	CECKR4_8	685	DEM
41	CECKR1_4_road	Weir	490,400	704,723	CECKR1_4	470	DEM
42	OldNaplesImmokaleeRoadWest	Weir	495,836	748,695	CorkscrwSE	6,955	DEM
43	OldNaplesImmokaleeRoadEast	Weir	497,873	749,507	CKMain	1,665	DEM
44	CR846_Road	Weir	490,514	739,259	CESC1	1,410	DEM
45	CR858_road	Weir	495,143	712,663	CECKR7	3,065	DEM
46	CECKR1_R1_Road	Weir	494,963	711,765	CECKR1	225	DEM
47	CECKR1_4_C1_svy	Weir	490,400	704,723	CECKR1_4	470	DEM
48	CR846_C2_road	Weir	499,474	739,105	CR846Conn1	640	DEM

Table 3.6 (continued)
Weirs Simulated in the Camp Keais Strand Model

Structure Number	Structure ID	Structure Type	X1 (ft)	Y1 (ft)	Branch	Chaninage	Data Source
49	CR846_C3_road	Weir	504,428	739,139	CR846Conn2	560	DEM
50	CECKR4_8_D15_road	Weir	492,563	691,595	CECKR4_8	6,750	DEM
51	CECKR4_8_D15	Weir	492,563	691,595	CECKR4_8	6,750	DEM
52	CECKR4_8_D18_road	Weir	491,652	690,793	CECKR4_8	7,250	DEM
54	CECKR4_8_D21_road	Weir	490,230	686,753	CECKR4_8	8,775	DEM
55	CEFUConn2_FarmBerm	Weir	490,124	676,080	CEFUConn2	1,315	DEM
56	I75N-5_Block	Weir	506,397	661,744	I75N-5	250	DEM
57	I75S-5_Block	Weir	506,397	660,760	I75S-5	250	DEM
58	BarronCollier-1-weir	Weir	502,466	692,558	CKMAINS	750	DEM
59	BarronCollier-2-weir	Weir	501,671	682,886	CKMAINS	4,100	DEM

Notes:
1 - NAD 1983 HARN State Plane Florida East (FIPS 0901 Feet)

Table 3.7
Quantitative surface water calibration statistics for the Camp Keais Strand model

Name	Data Type	1995 - 1999					
		ME (ft)	MAE (ft)	RMSE (ft)	STDres (ft)	Correlation Coefficient ( )	Nash Sutcliffe ( )
FU-4 Headwater	stage	-1.06	1.36	1.62	1.23	0.72	0.13
Camp Keais Strand on CR 846	stage	-0.39	0.44	0.65	0.52	0.75	0.18
Camp Keais Strand on CR 858	stage	-0.21	0.34	0.62	0.59	0.73	0.34
Lake Trafford	stage	-0.18	0.35	0.48	0.44	0.80	0.48
Lucky Lake Headwater	stage	-0.74	1.03	1.39	1.17	0.35	-0.32
Lucky Lake Tailwater	stage	-0.42	0.44	0.46	0.19	0.92	0.06

Table 3.8
Quantitative Groundwater Calibration Statistics for the Camp Keais Strand Model

Name	Data type	1995 - 1999					
		ME (ft)	MAE (ft)	RMSE (ft)	STDres (ft)	Correlation Coefficient ( )	Nash Sutcliffe ( )
C-503	water level	-0.83	1.32	1.55	1.31	0.65	-1.95
C-531	water level	-3.45	4.18	5.38	4.13	0.76	0.26
C-598	water level	-0.62	1.28	1.48	1.34	0.77	0.27
C-690	water level	-0.39	0.73	0.92	0.84	0.71	0.36
C-988	water level	-2.02	2.36	2.87	2.04	0.54	-0.62
C-1079	water level	-4.27	4.29	5.46	3.41	0.52	-1.12

Table 4.1
Structure Dimensions for Existing Conditions (Scenario 0)

Structure	Span / Size (ft)	Bottom Width (ft)	Abutment Width (ft)	Canal Low Point / Invert Elevations (ft NAVD 88)	Abutment Bottom Elevation (ft NAVD 88)	Low Chord Elevation (ft NAVD 88)	Road Surface Elevation (ft NAVD 88)
Culvert on CR858 at Camp Keais Strand	1 x 3.5' diam. x 50'	NA[1]	NA	14.35 u.s. / 14.45 d.s.	NA	NA	NA
Existing Bridge on CR858 at Camp Keais Strand	119	101	18	12.5	14.3	20.1	22.1
Existing Bridge on CR858 at Faka Union Canal[2]	96.3	60.1	36.2	4.7	10.1	15.7	15.7[3]
Existing Bridge on CR846 at Camp Keais Strand	105	85	16.8	13.5	16.5	23.6	27.2
North Barron-Collier Farm Culverts (estimated dimensions)	2 x 4' diam. x 40'	NA	NA	12.7 u.s. / 12.3 d.s.	NA	NA	19.2
South Barron-Collier Farm Culverts (estimated dimensions)	2 x 4' diam. x 40'	NA	NA	11.8 u.s. / 11.4 d.s.	NA	NA	18.3

[1] Not Applicable.
[2] Bridge geometry from UNET cross-section (Dames and Moore, 1998).
[3] Top elevation of UNET cross-section elevation used as road surface elevation.

Table 4.2
Structure Dimensions for Scenarios 1 to 3

Structure	Span / Size (ft)	Bottom Width (ft)	Abutment Width (ft)	Canal Low Point / Invert Elevation (ft NAVD 88)	Abutment Bottom Elevation (ft NAVD 88)	Low Chord Elevation (ft NAVD 88)	Road Surface Elevation (ft NAVD 88)
Proposed Bridge on CR858 at Camp Keais Strand (Location 1)	180	115	31.7	12.5	12.5	24.75	29.5
Proposed Culvert on CR858 at Camp Keais Strand (Location 2)	2 x 12' x 6' x 100'	NA[1]	31.5	13.0 u.s. / 13.0 d.s.	NA	NA	NA
Proposed Modified Bridge on CR858 at Faka Union Canal (Location 3)	120	60.8	59.2	4.7	4.7	19.5	24.3
Proposed Modified Bridge on CR846 at Camp Keais Strand (Location 4)	180	115	31.7	13.5	13.5	25.8	30.5
Proposed Modified North Barron-Collier Farm Culverts (Location 5)	4 x 4' diam. x 40'	NA	NA	12.7 u.s. / 12.3 d.s.	NA	NA	19.2
Proposed Modified South Barron-Collier Farm Culverts (Location 6)	4 x 4' diam. x 40'	NA	NA	11.8 u.s. / 11.4 d.s.	NA	NA	18.3

[1] Not Applicable

Table 5.1
Geometry of Proposed Features

Location	Existing Feature	Existing Geometry	New Feature	New Geometry
CR 846 at Camp Keais Strand	*Bridge*	Low Chord 23.574 ft NAVD Bridge Top 27.241 ft NAVD Low Point 13.507 ft NAVD Flowway length 105 ft Piers 0.073% of flowway length	*Bridge*	Low Chord 25.757 ft NAVD Bridge Top 30.507 ft NAVD Low Point 13.507 ft NAVD Flowway length 180 ft Piers 0.025% of flowway length
CR 858 at Camp Keais Strand	*Bridge*	Low Chord 20.107 ft NAVD Bridge Top 22.112 ft NAVD Low Point 12.507 ft NAVD Flowway length 125 ft Piers 0.067% of flowway length	*Culvert*	2 x 110’ x 12’ x 6’ box culverts U/S invert 13 ft NAVD D/S invert 13 ft NAVD
CR 858 at Camp Keais Strand	*Culvert*	1 x 50’ x 3.5’ circ. culverts U/S invert 14.35 ft NAVD D/S invert 14.45 ft NAVD	*Bridge*	Low Chord 24.75 ft NAVD Bridge Top 29.5 ft NAVD Low Point 12.5 ft NAVD Flowway length 180 ft Piers 0.025% of flowway length
Old Railroad Grade South of CR 858	*Railroad grade*	Railroad grade elevation 18 ft NAVD 100 ft flowway length	*Degraded railroad grade*	500 ft length degraded to 16.418 ft NAVD
Barron Collier North Farm Road	*Farm road with culverts*	2 x 40’ x 4’ circ. culverts U/S invert 12.7 ft NAVD D/S invert 12.3 ft NAVD Estimated road bed elevation at 19.2 ft NAVD	*Farm road with improved culverts*	4 x 40’ x 4’ circ. Culverts ***** U/S invert 12.7 ft NAVD D/S invert 12.3 ft NAVD Estimated road bed elevation at 19.2 ft NAVD
Barron Collier South Farm Road	*Farm road with culverts*	2 x 40’ x 4’ circ. culverts U/S invert 11.8 ft NAVD D/S invert 11.4 ft NAVD Estimated road bed elevation at 18.3 ft NAVD	*Farm road with improved culverts*	4 x 40’ x 4’ circ. Culverts ***** U/S invert 11.4 ft NAVD D/S invert 11.4 ft NAVD Estimated road bed elevation at 18.3 ft NAVD

* or a combination of 24”, 30” and 36” circular culverts for a total conveyance capacity of 320 cfs.

Table 5.2
Cost Estimate - Hydraulic Improvements Camp Keais Strand Flowway

1.0	**Scenario 1 - Modification of Hydraulic Components**	
1	Replacement of the existing culvert on CR 858 with the 6-lane bridge design developed by CH2M HILL	$2,166,800
2	Replacement of the existing Camp Keais Strand Bridge on CR 858 with the culvert design	$1,248,000
Total	Total Scenario 1	$3,414,800
2.0	**Scenario 2 - Modification of Hydraulic Components**	
1	Degrade 500 ft of the old rail road grade south of CR 858 to natural grade	$4,300
2	Replacement of the existing bridge on CR 846 with the 6-lane bridge design developed by CH2M HILL for CR 858 at the Camp Keais Strand	$2,346,800
3	Replacement of the Barron-Collier farm culverts under one of the two farm roads that cross the main Camp Keais Strand flowway	$17,100
4	Replacement of the Barron-Collier farm culverts under one of the two farm roads that cross the main Camp Keais Strand flowway	$17,100
Total	Total Scenario 2	$2,385,300
TOTAL ALL SCENARIOS		$5,800,100

FIGURES

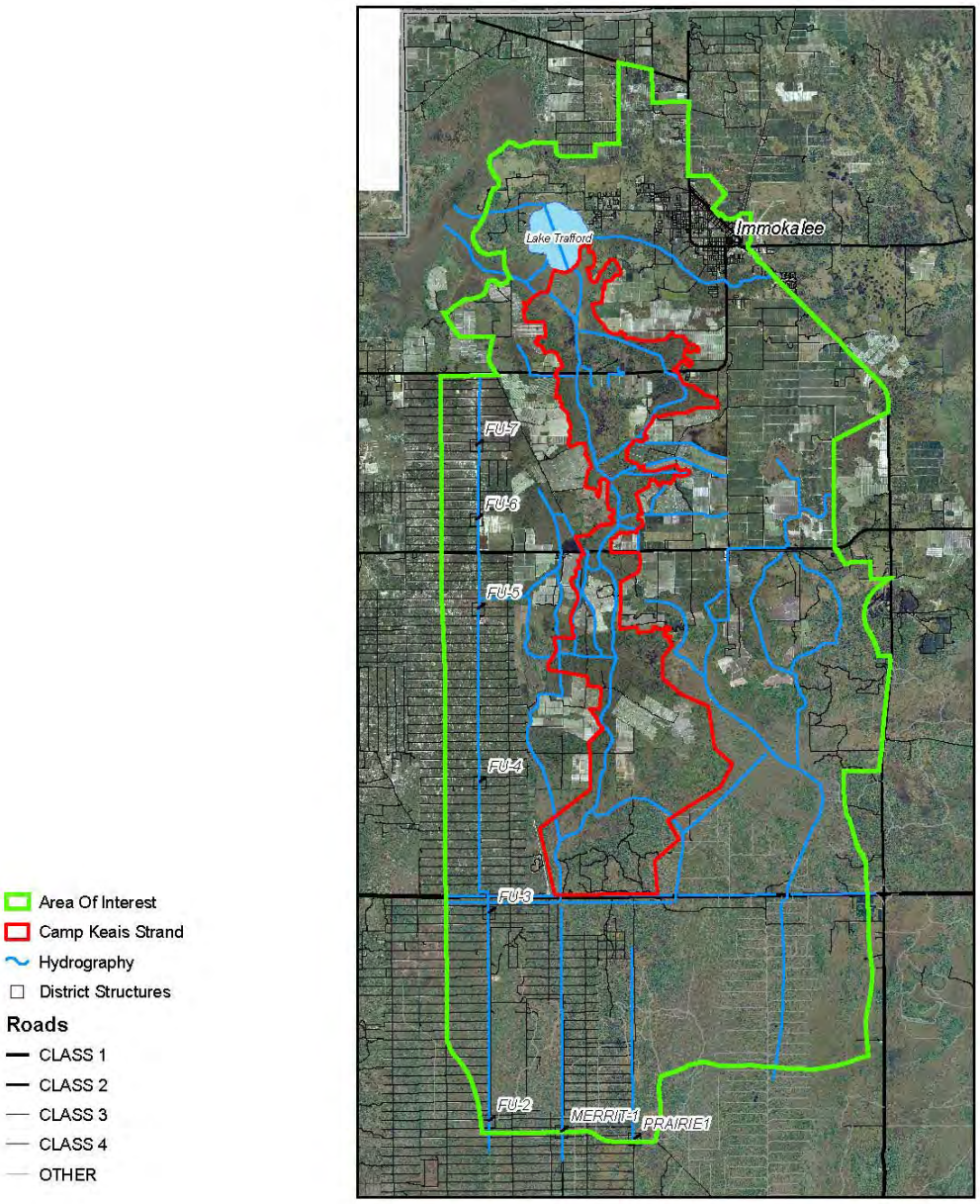

Figure 1.1 Project Area

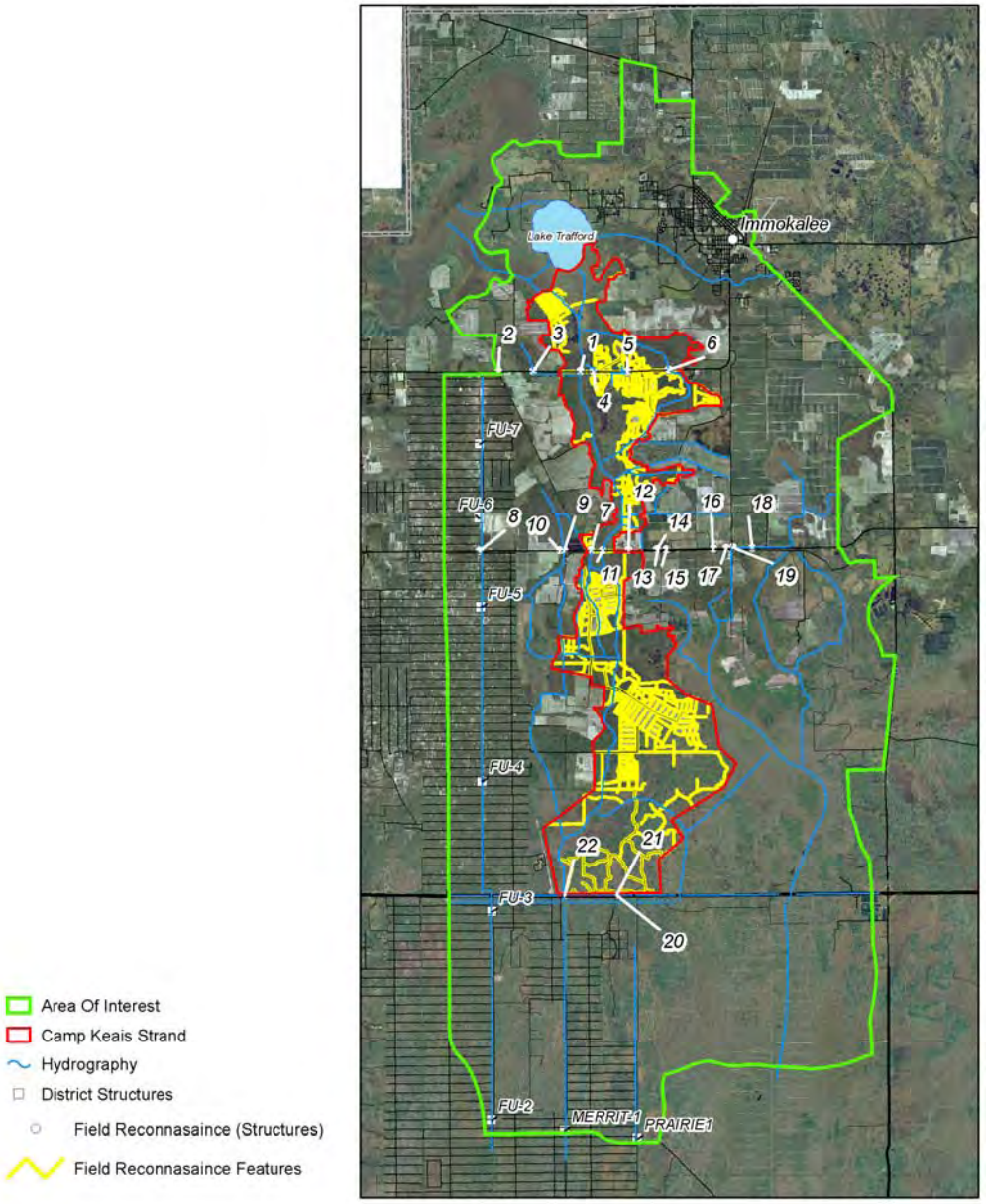

Figure 2. 1 Locations of Structures and Flowway Obstructions Observed During Windshield Survey and Aerial Photograph Analysis.

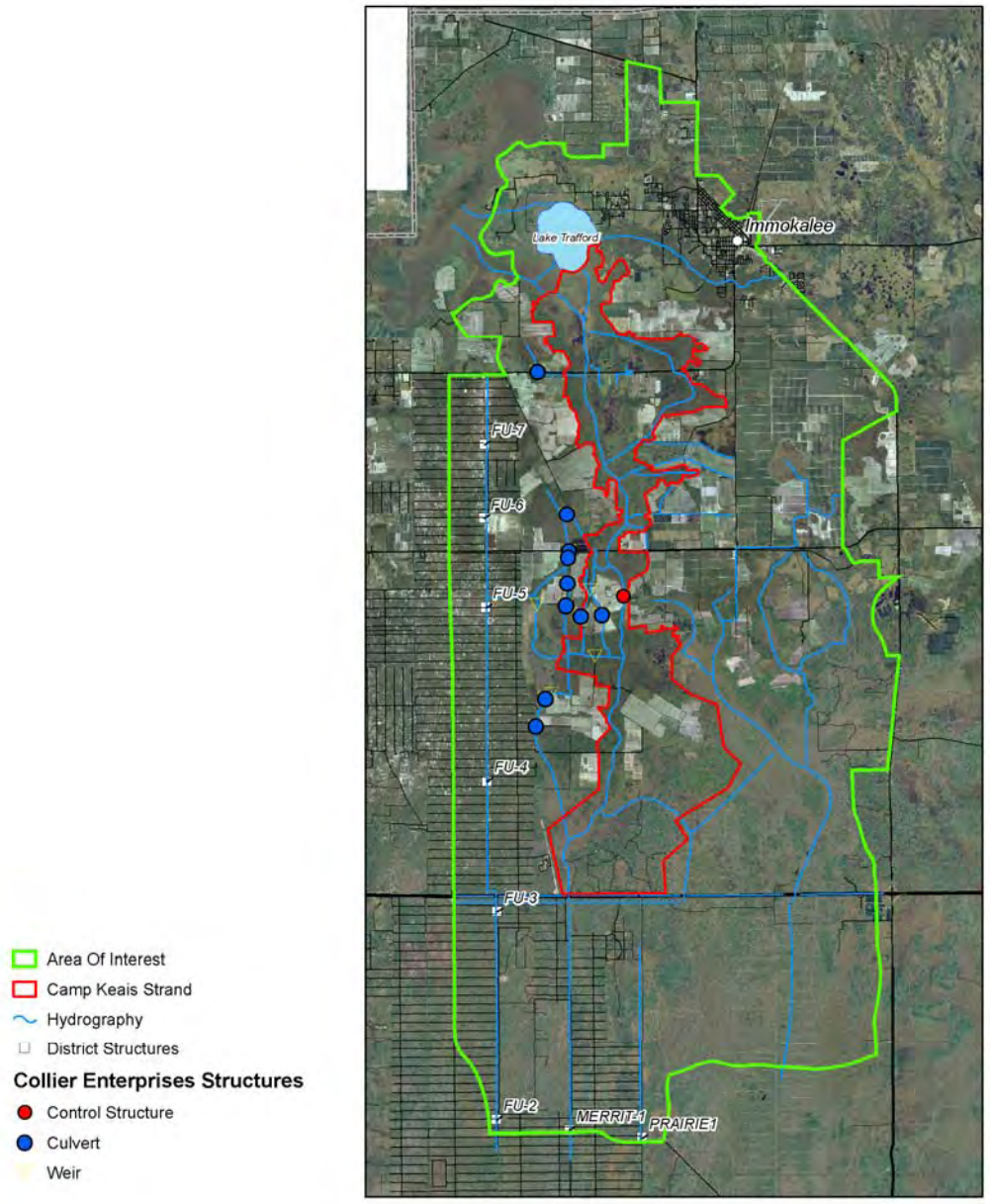

Figure 2.2 Locations of Structure Data Provided by Collier Enterprises.

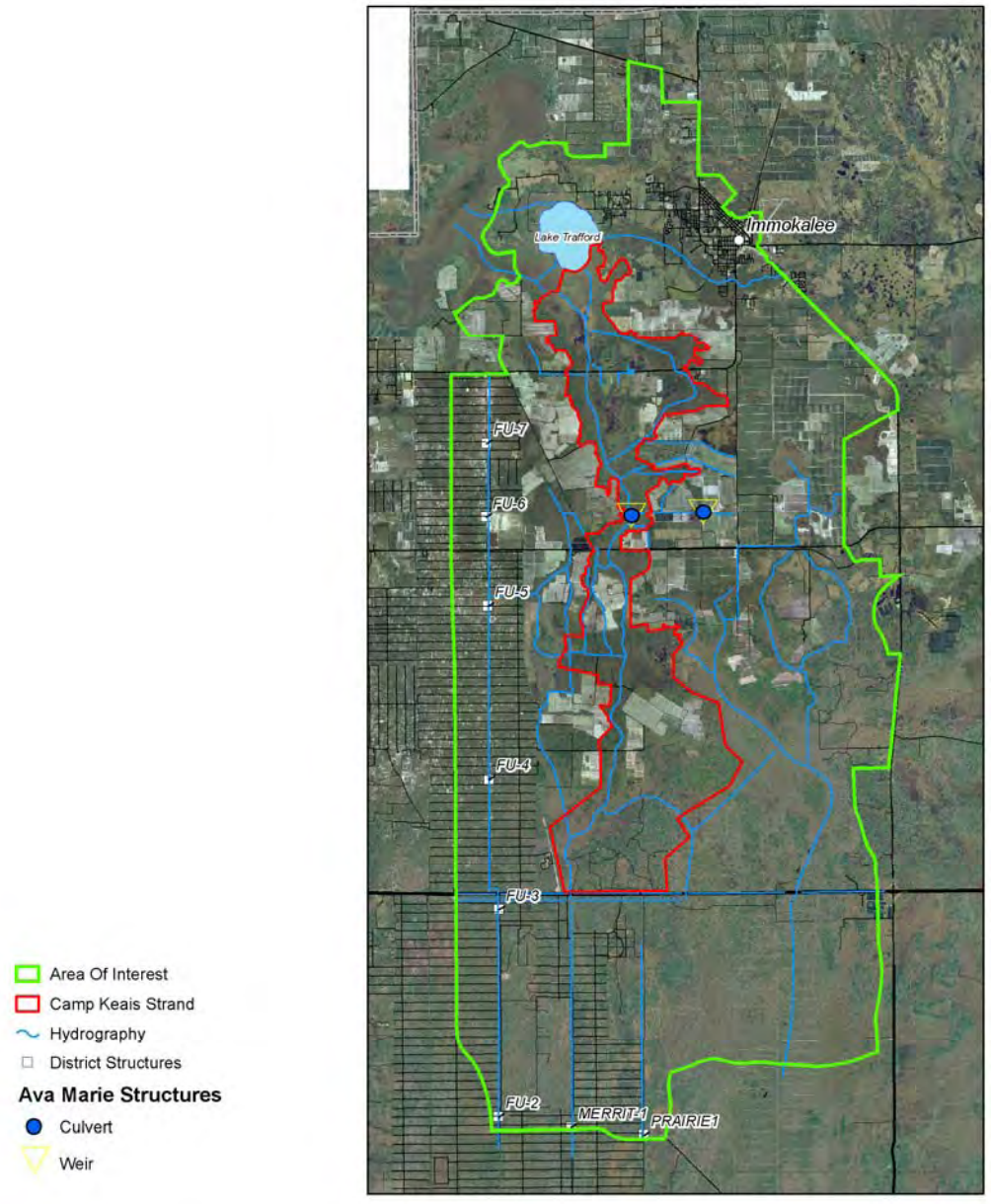

Figure 2.3 Locations of Structure Data in the Ave Maria Area.

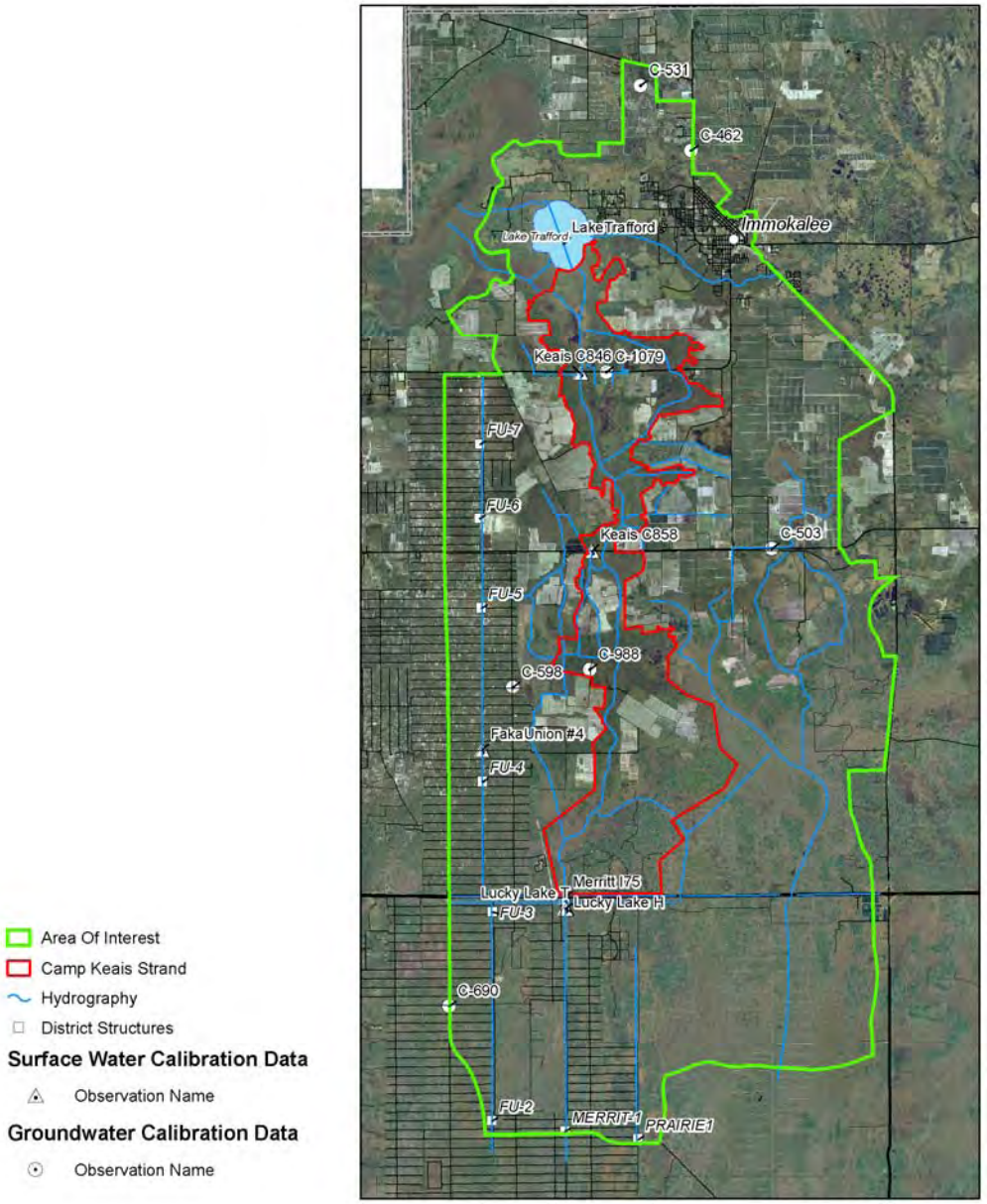

Figure 2.4 Location of Surface Water Gages and Groundwater Observation Wells in the Vicinity of Camp Keais Strand.

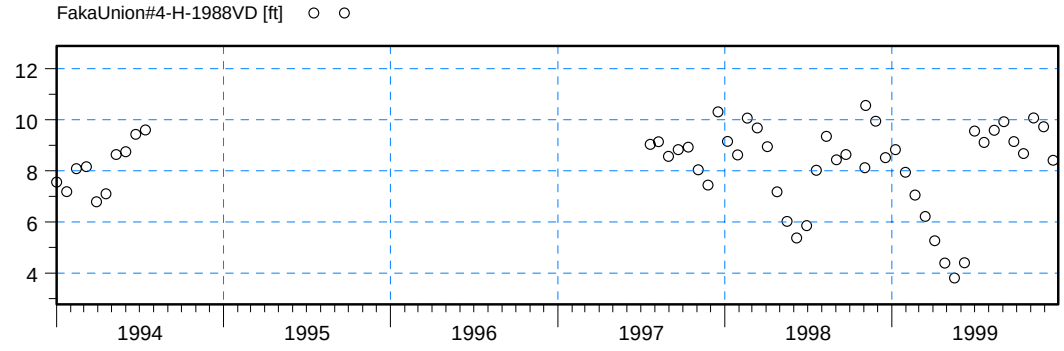

Figure 2.5 Observed Stages at the Headwater Side (North) of FakaUnion #4 on Faka Union Canal (ft NAVD 1988).

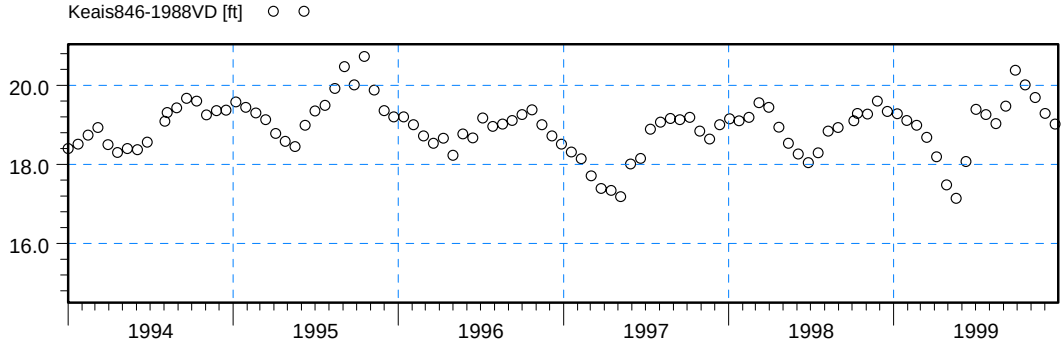

Figure 2.6 Observed Stages at the Tailwater Side (South) of the Bridge on Camp Keais Strand at CR 846 (ft NAVD 1988).

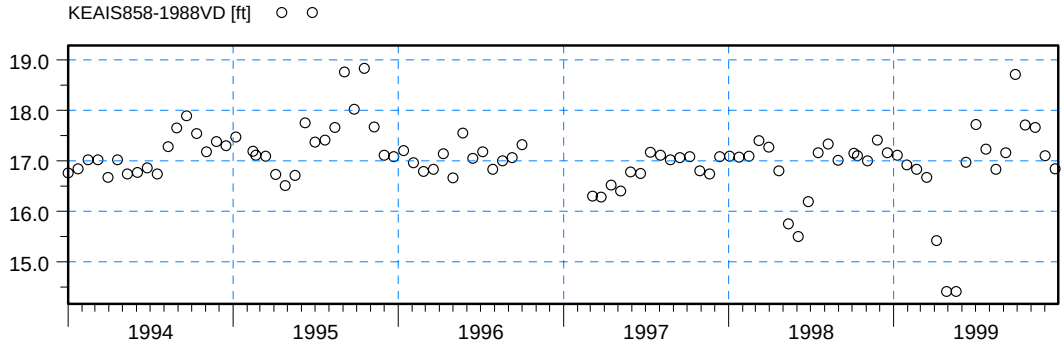

Figure 2.7 Observed Stages at the Headwater Side (North) of the Bridge on Camp Keais Strand at CR 858 (ft NAVD 1988).

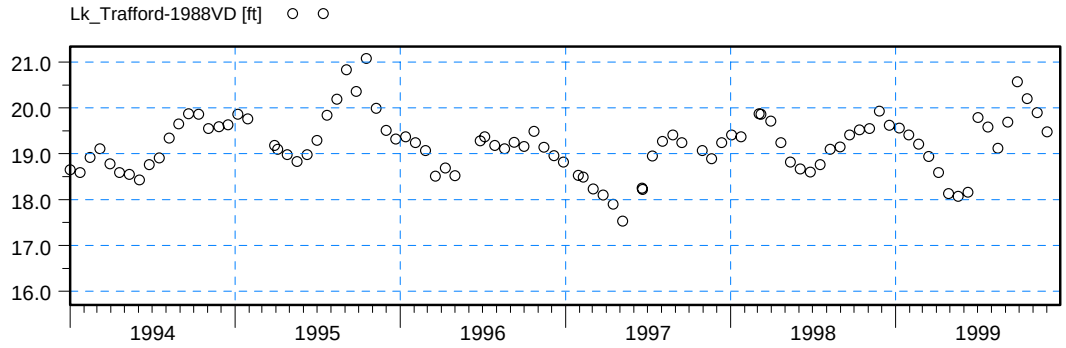

Figure 2.8 Observed Stages at Lake Trafford (ft NAVD 1988).

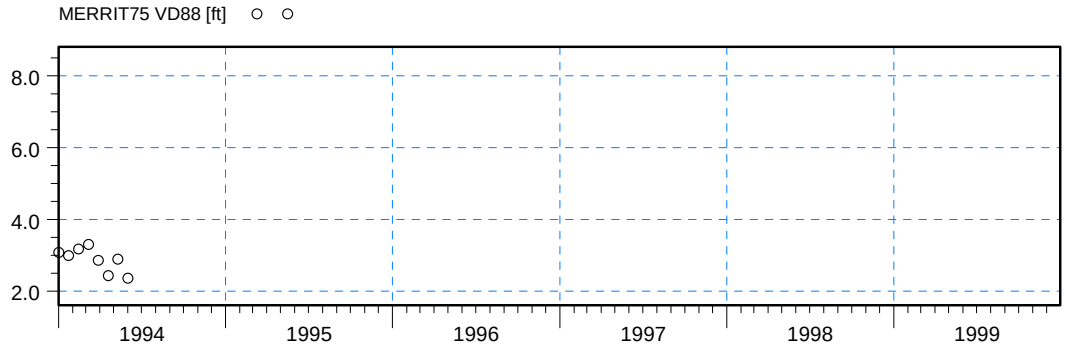

Figure 2.9 Observed Stages at the Tailwater Side (South) of the bBidge at I-75 on Merritt Canal (ft NAVD 1988).

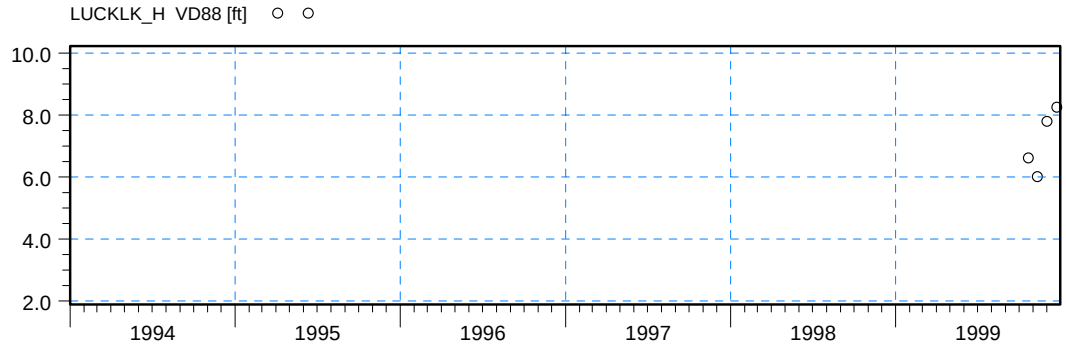

Figure 2.10 Observed Stages at the Headwater Side (North) of Lucky Lake Weir on Merritt Canal (ft NAVD 1988).

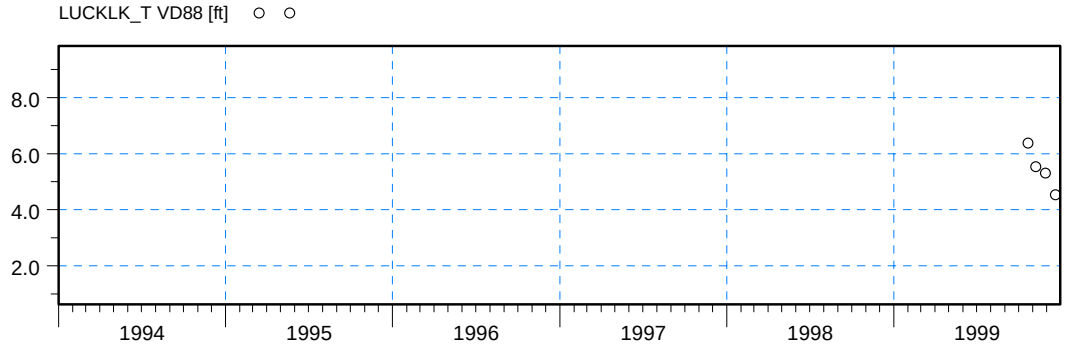

Figure 2.11 Observed Stages at the Tailwater side (South) of Lucky Lake Weir on Merritt Canal (ft NAVD 1988).

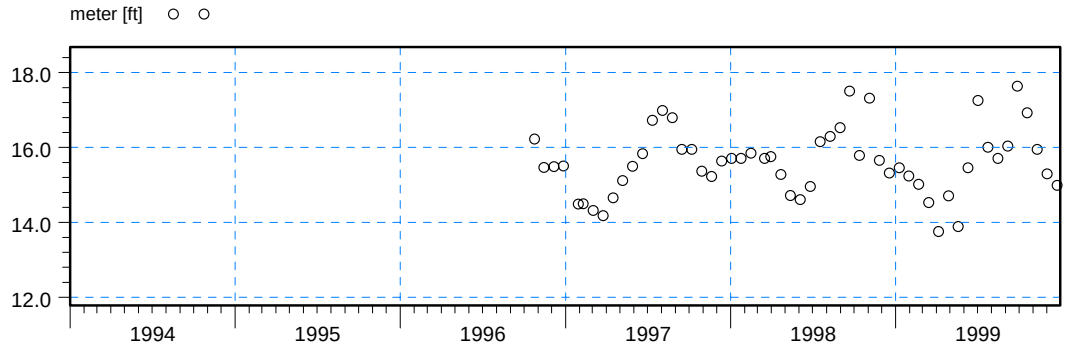

Figure 2.12 Observed Groundwater Levels at C-503 (ft NAVD 1988).

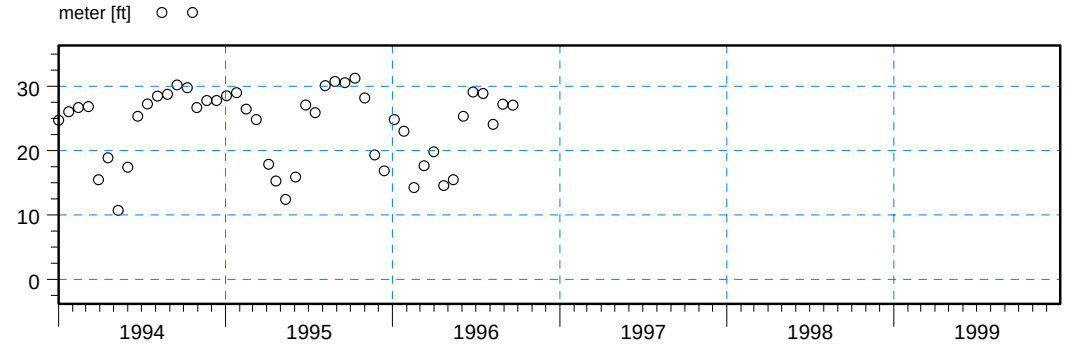

Figure 2.13 Observed Groundwater Levels at C-531 (ft NAVD 1988).

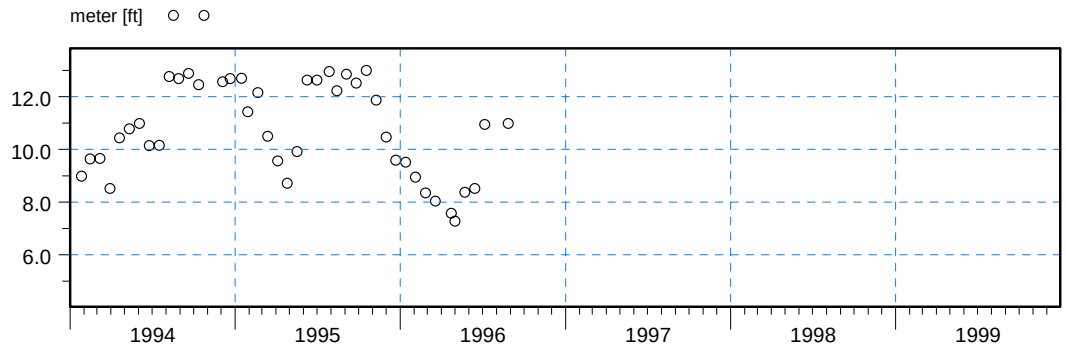

Figure 2.14 Observed Groundwater Levels at C-598 (ft NAVD 1988).

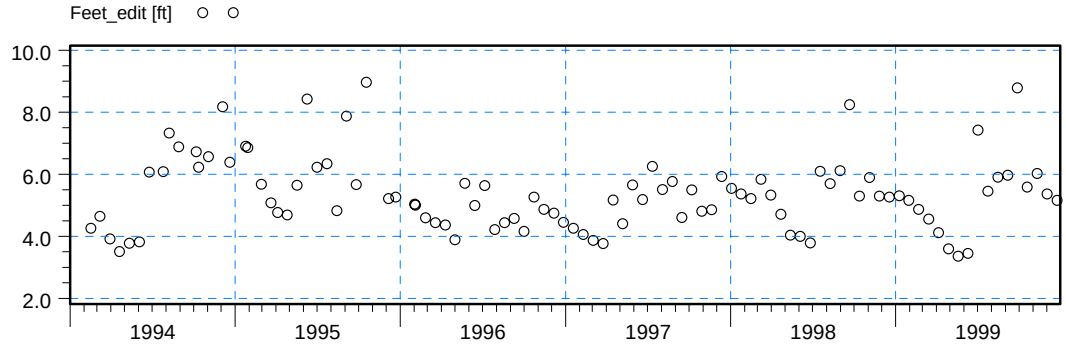

Figure 2.15 Observed Groundwater Levels at C-690 (ft NAVD 1988).

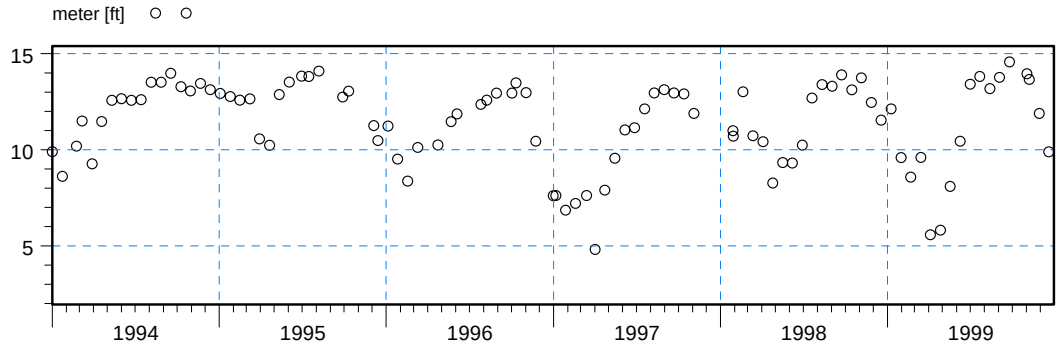

Figure 2.16 Observed Groundwater Levels at C-988 (ft NAVD 1988).

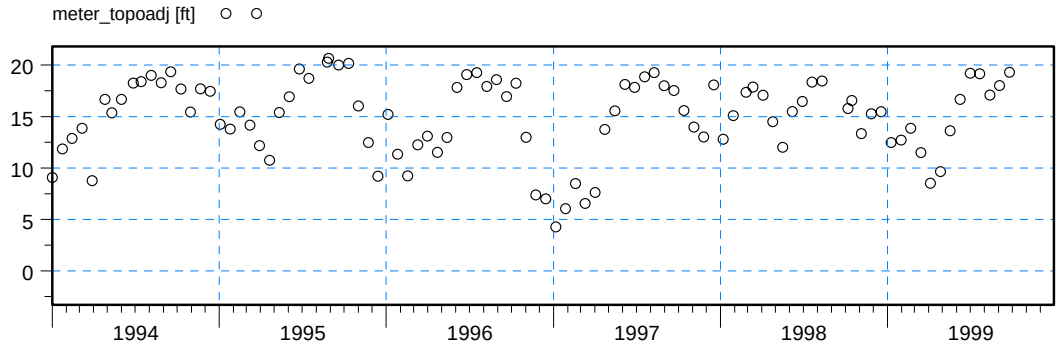

Figure 2.17 Observed Groundwater Levels at C-1079 (ft NAVD 1988).

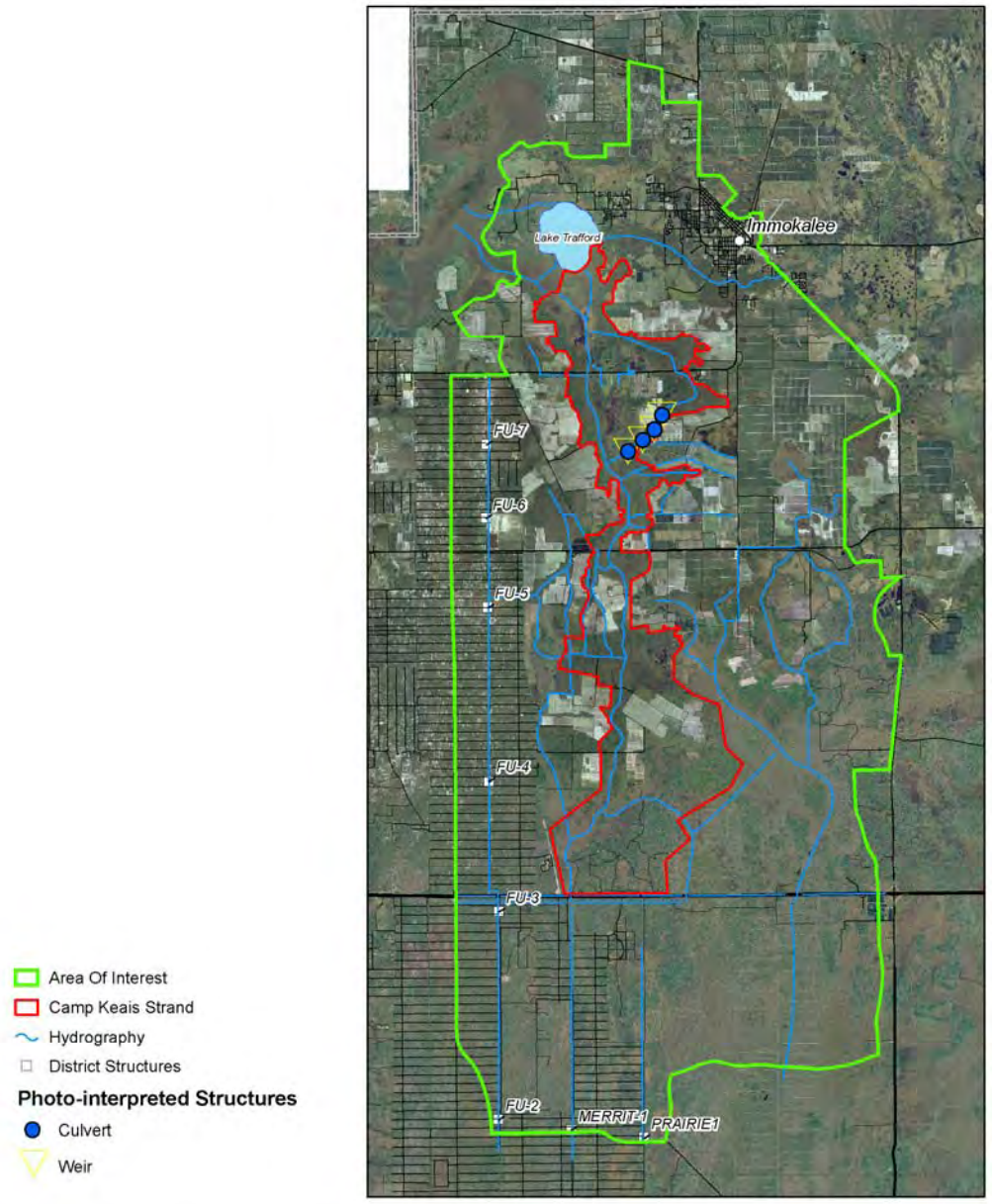

Figure 2.18 Locations of Photo-Interpreted Structures in Camp Keais Strand.

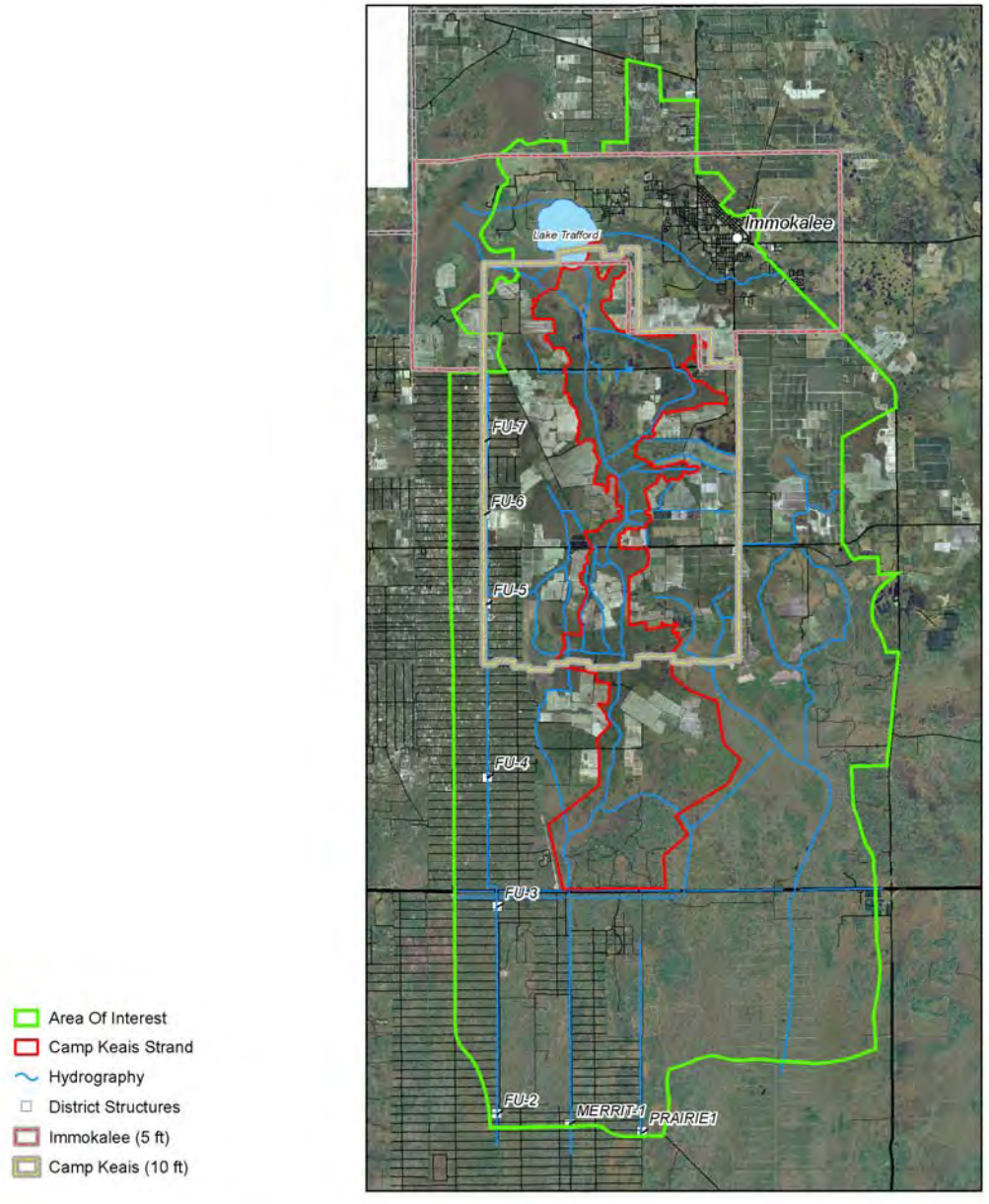

Figure 2.19 Location of Areas with High Resolution Photogrammetric Topographic Data.

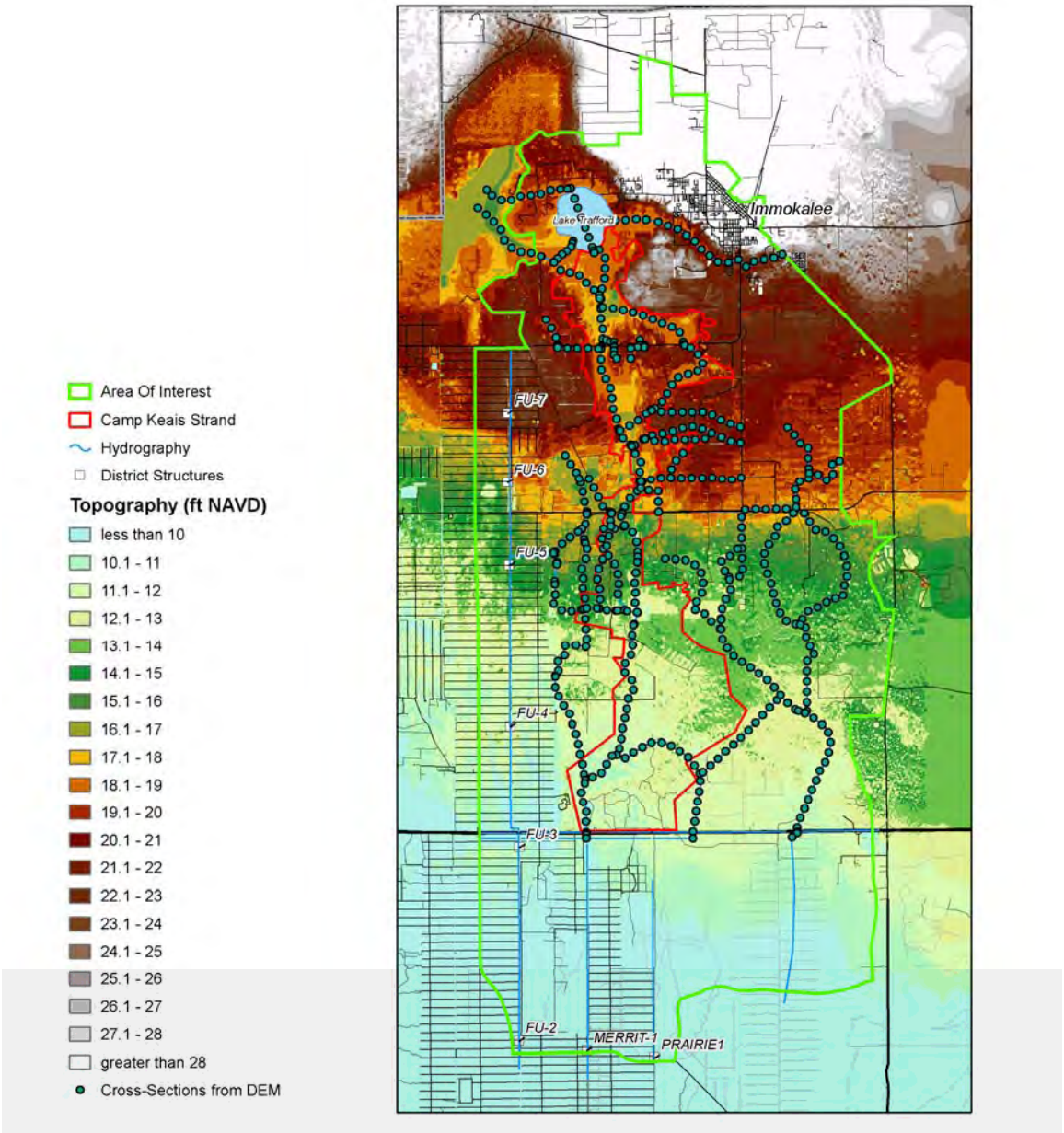

Figure 2.20 Digital elevation model for the Camp Keais Strand Area developed from the best available topographic area for the data (ft NAVD). The locations for cross-sections extracted from the digital elevation model are also shown. The digital elevation model has a maximum horizontal resolution of 100 ft.

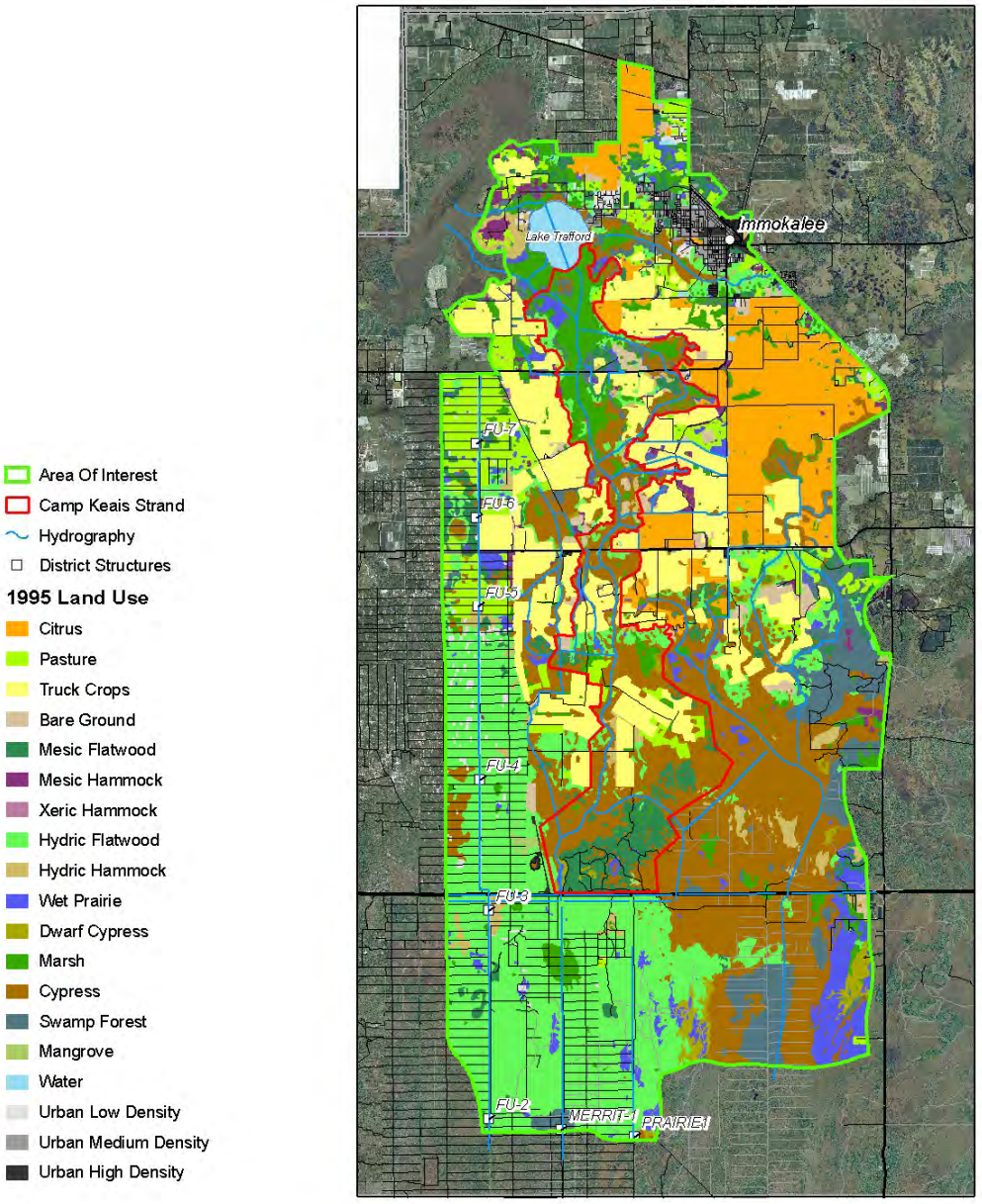

Figure 2.21 1995 Land-Use Data for the Camp Keais Strand Area.

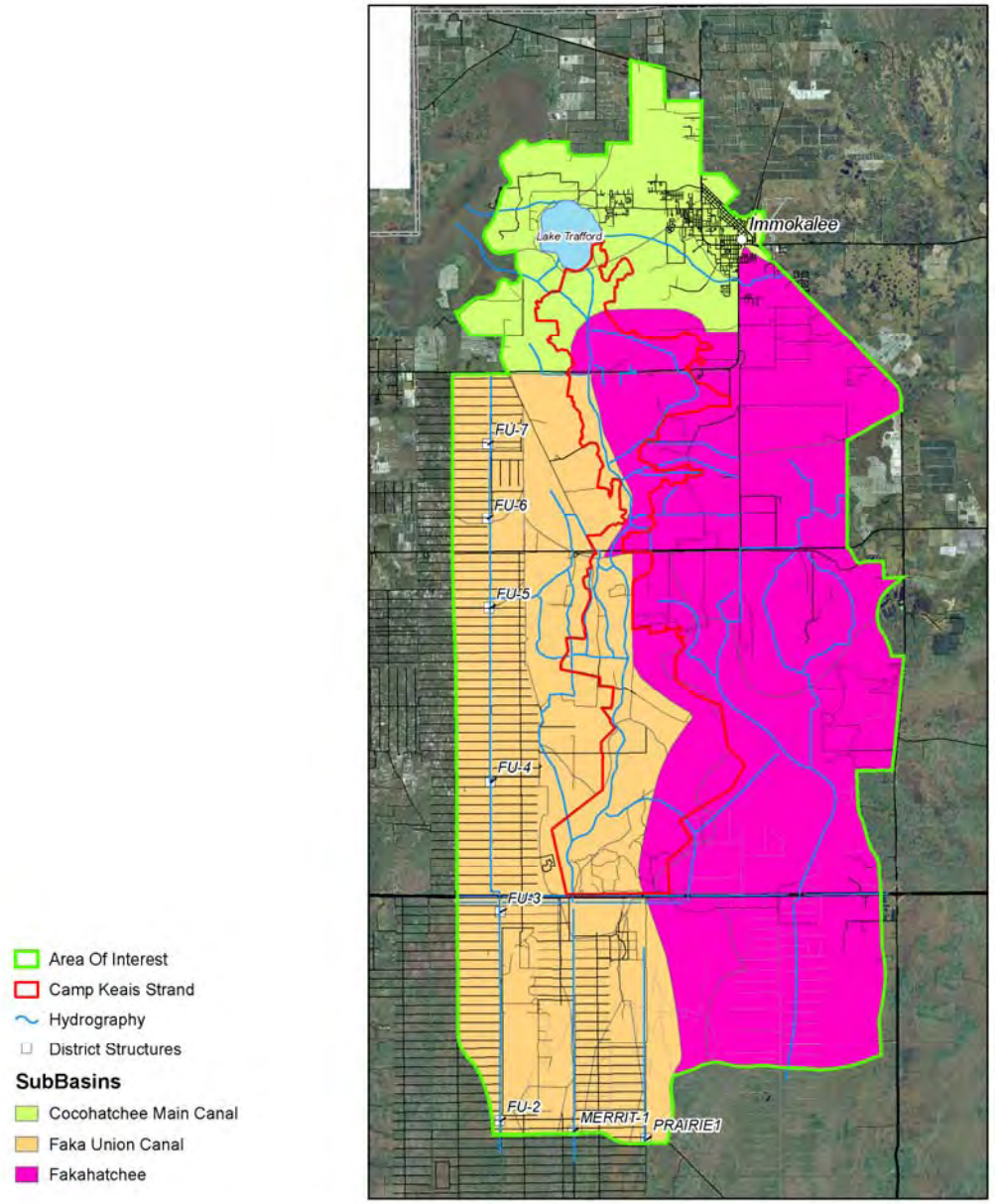

Figure 2.22 Major Surface Water Sub-Basins Defined by SFWMD for the Camp Keais Strand Area.

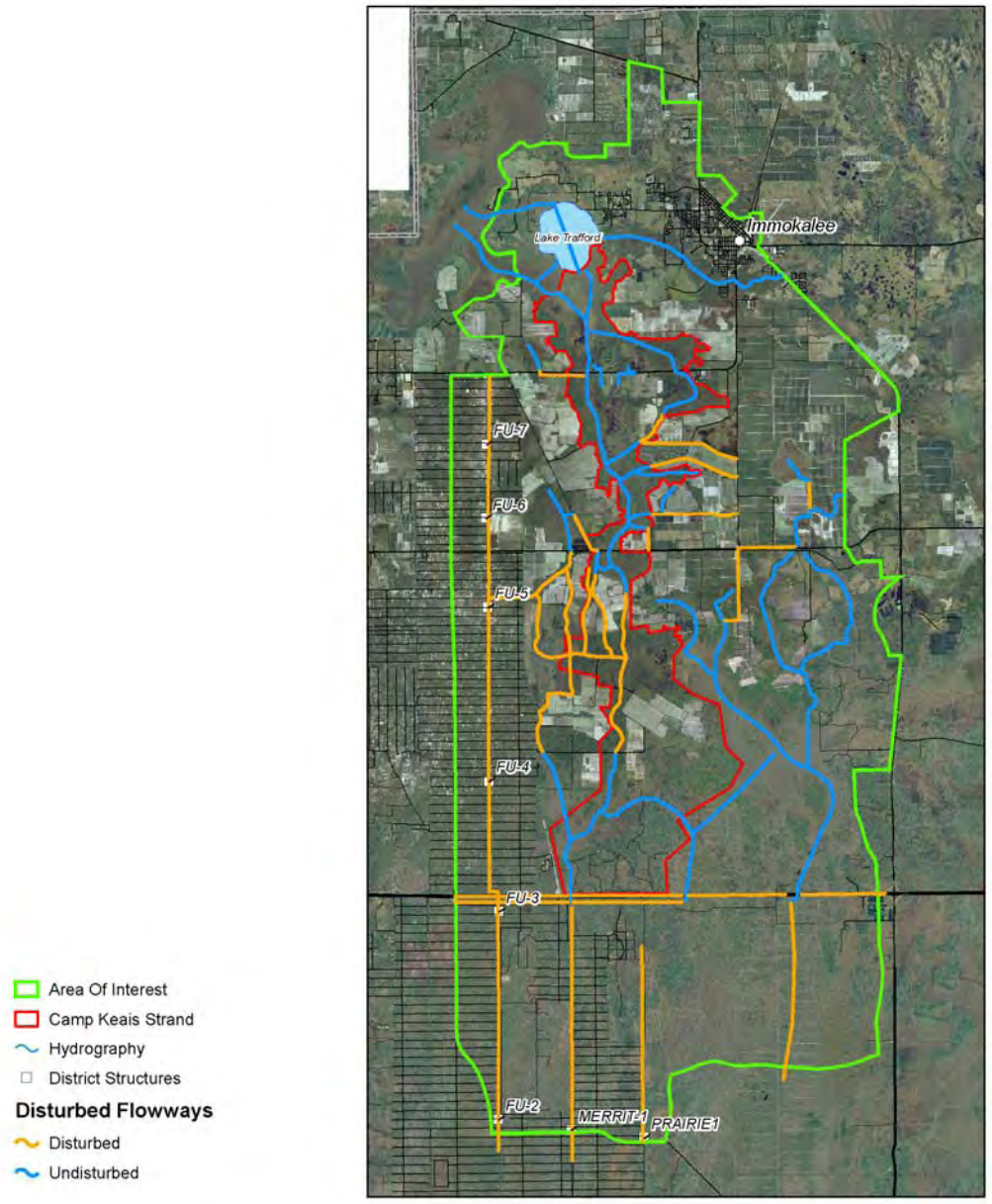

Figure 2.23 Disturbed and Undisturbed Flowways in the Camp Keais Strand Area.

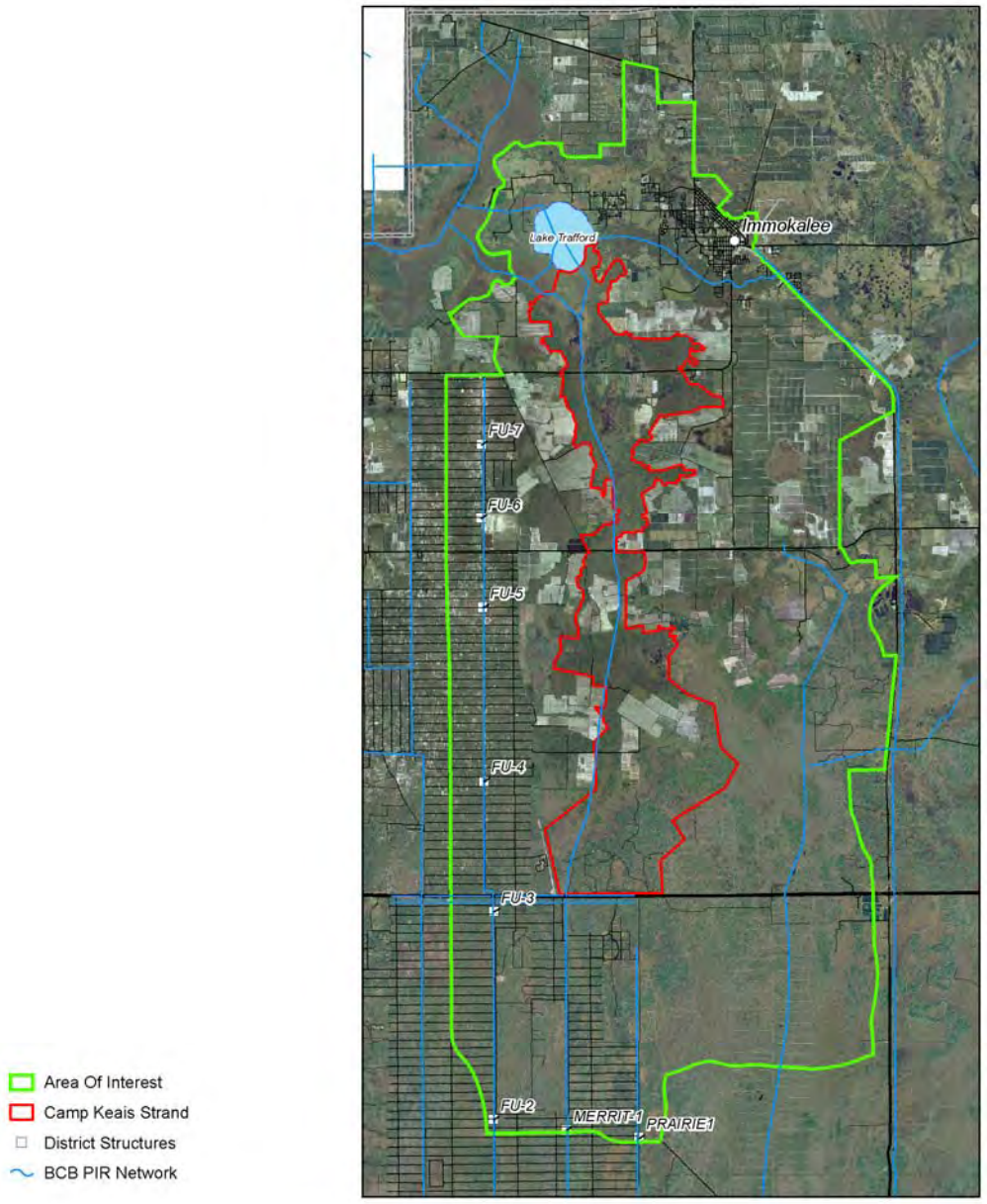

Figure 3.1 MIKE 11 Network Used in the PSRP Model.

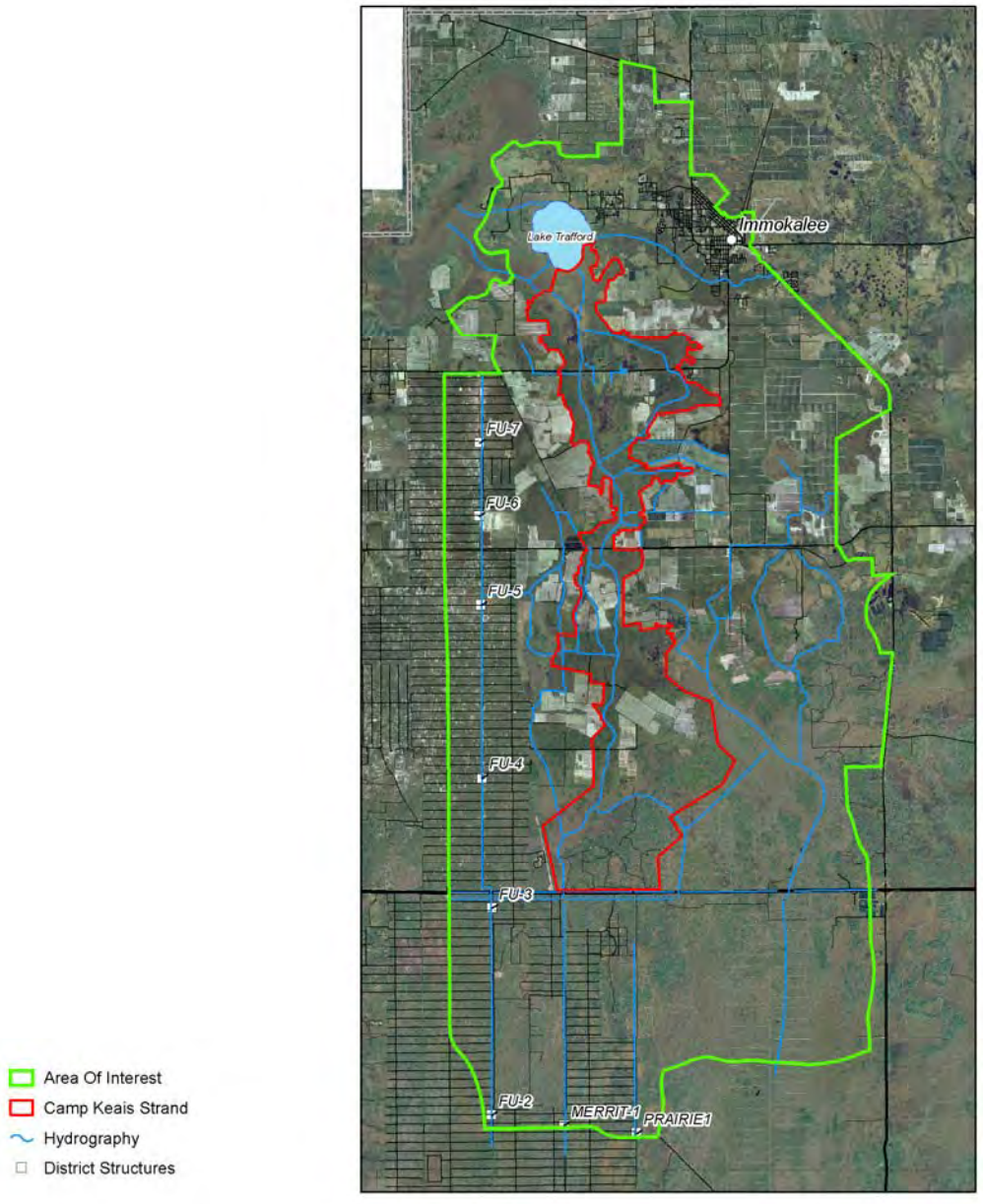

Figure 3.2 MIKE 11 Network Used in the Camp Keais Strand Model.

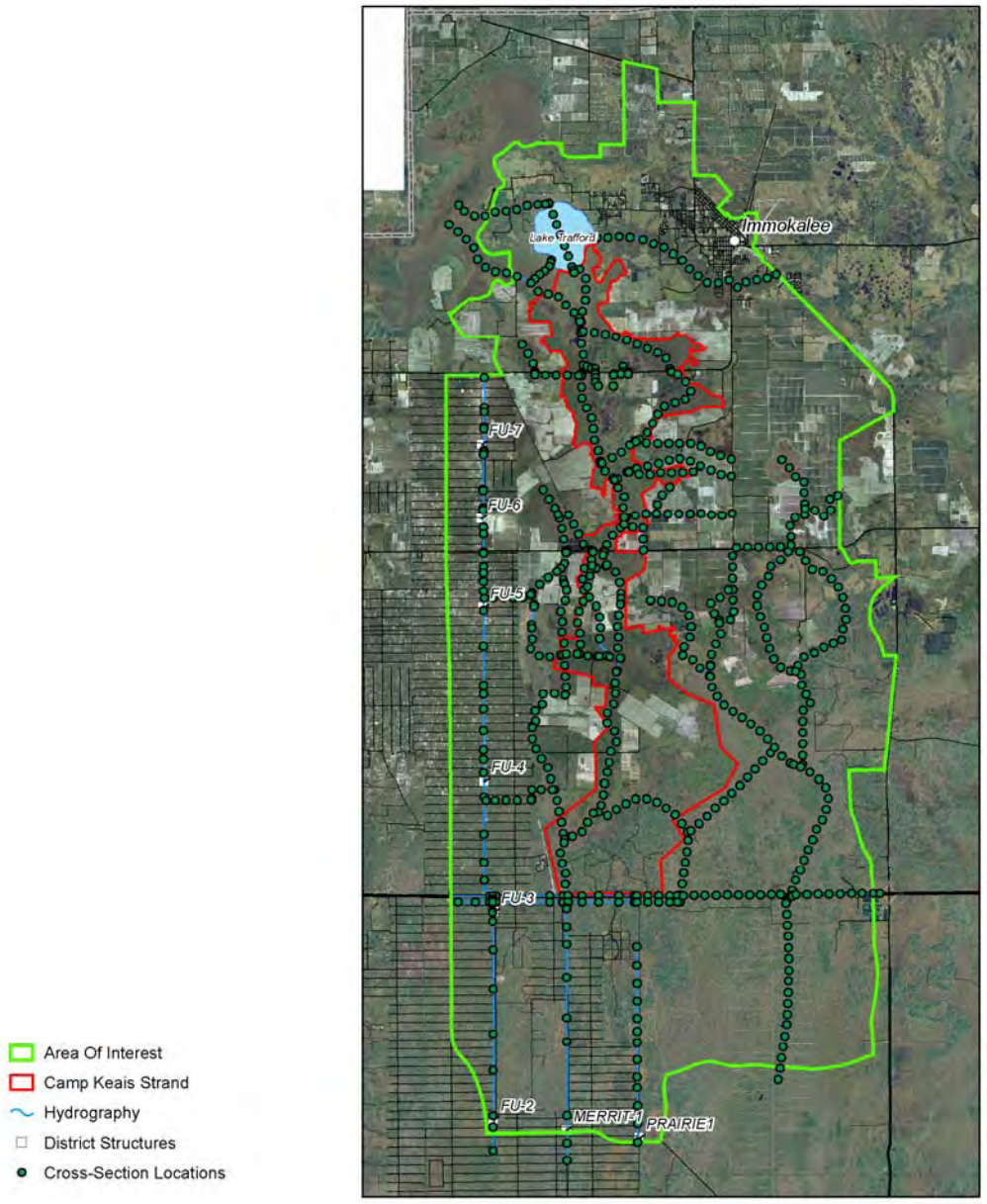

Figure 3.3 Cross-Sections Used in the Camp Keais Strand MIKE 11 Model.

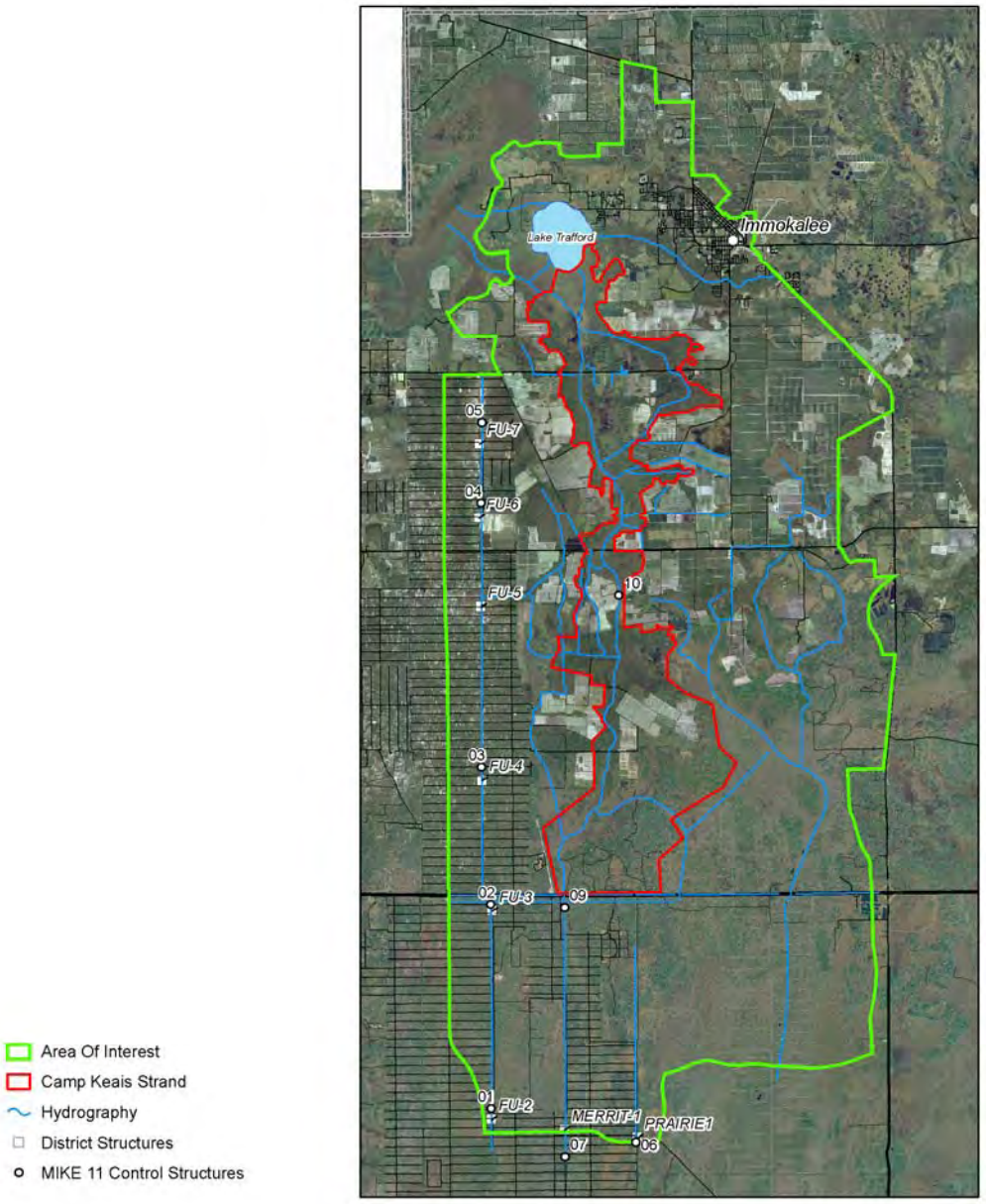

Figure 3.4 Control Structures Simulated in the Camp Keais Strand MIKE 11 Model.

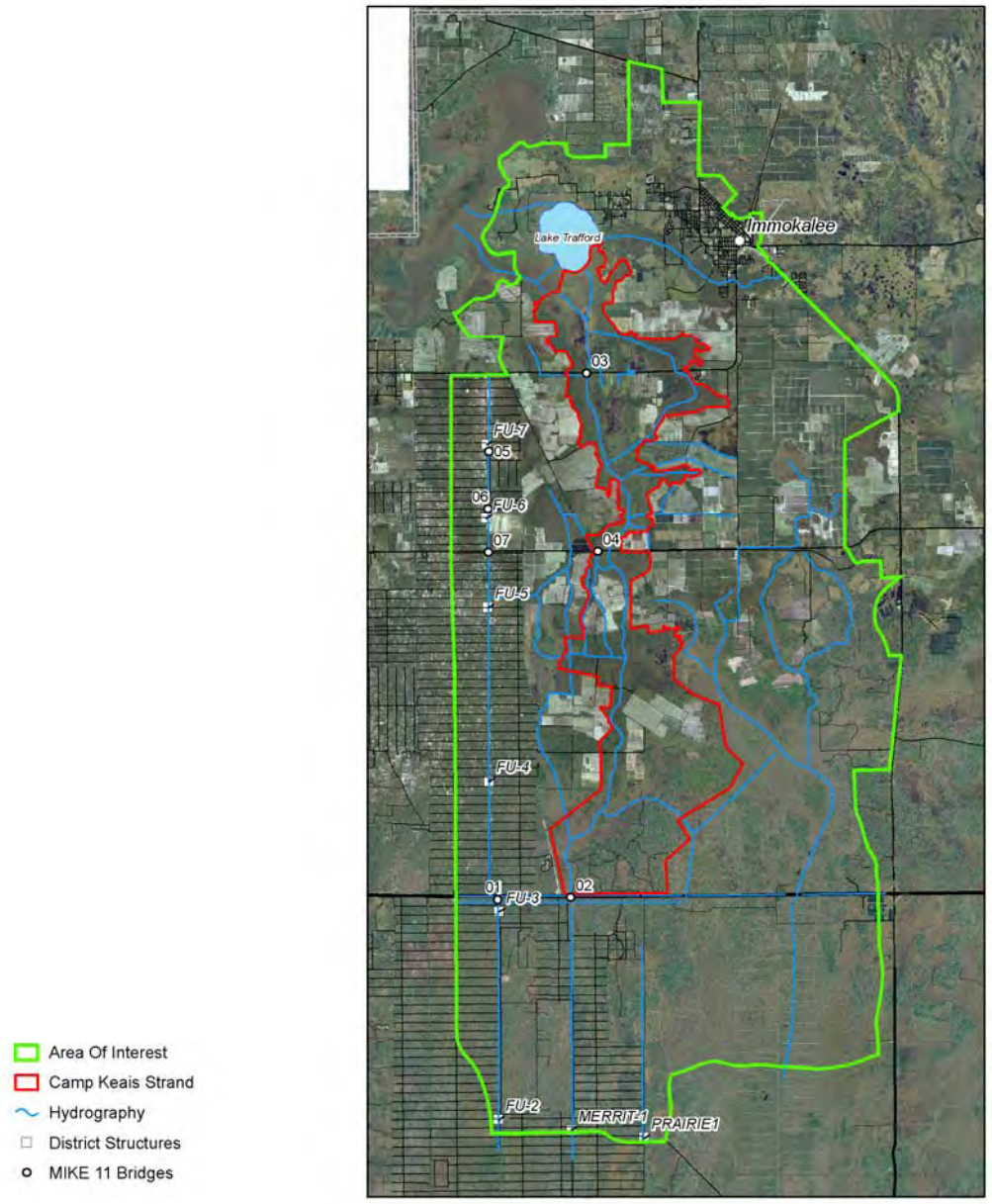

Figure 3.5 Bridges Simulated in the Camp Keais Strand MIKE 11 Model.

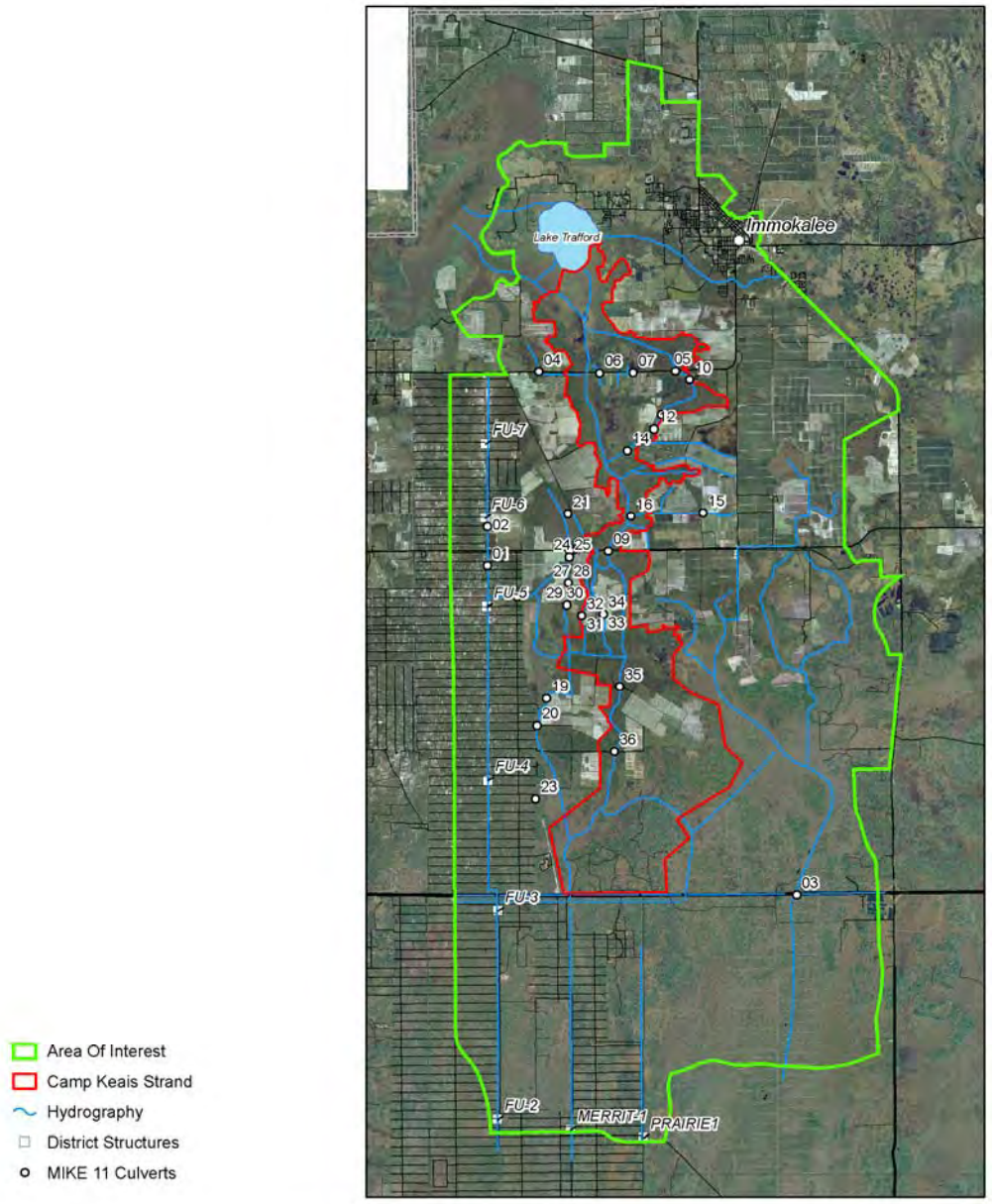

Figure 3.6 Culverts Simulated in the Camp Keais Strand MIKE 11 Model.

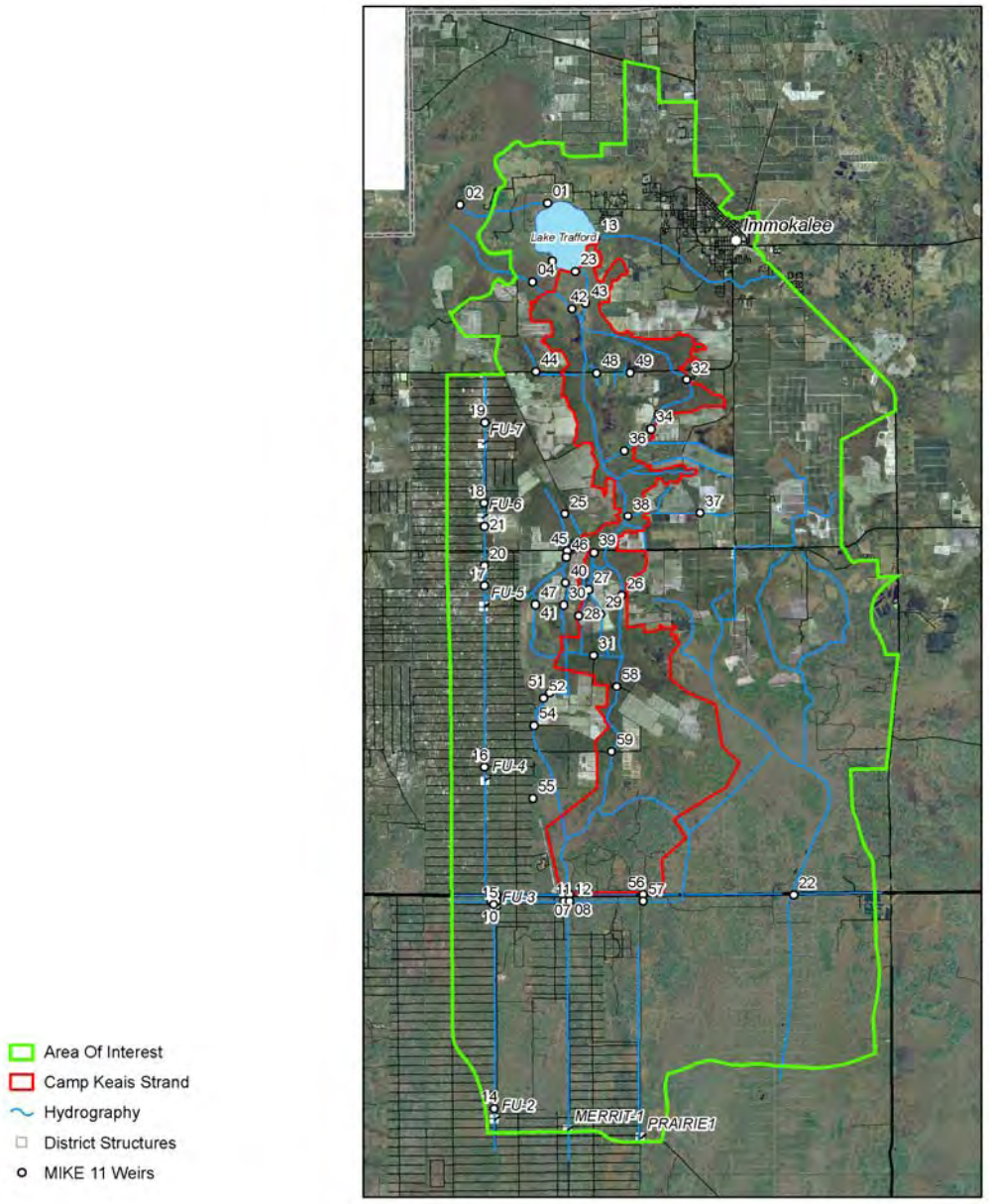

Figure 3.7 Weirs Simulated in the Camp Keais Strand MIKE 11 Model.

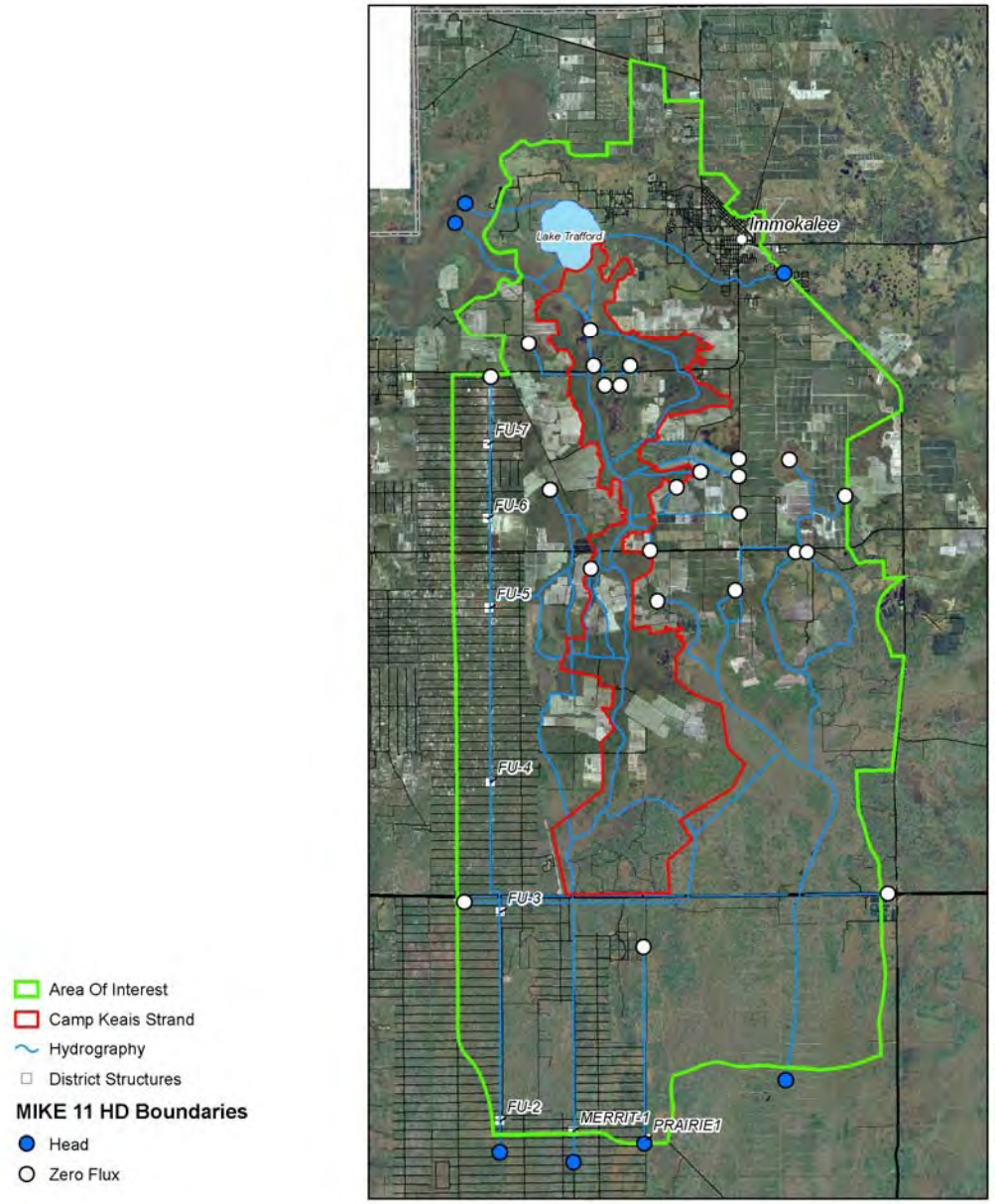

Figure 3.8 Hydrodynamic Boundary Conditions Used in the Camp Keais Strand MIKE 11 Model.

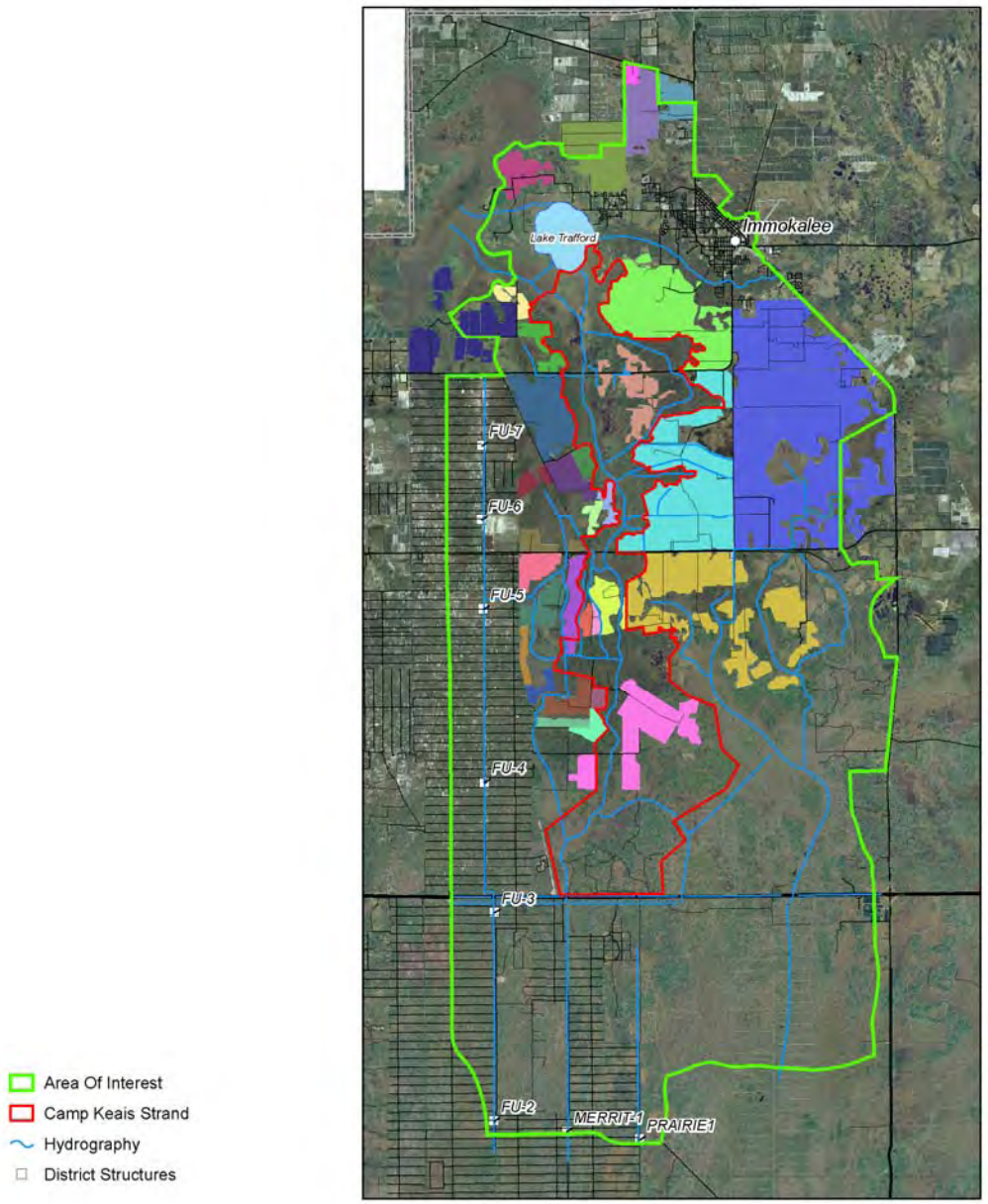

Figure 3.9 Agricultural Areas Represented in a More Refined Manner in the Drainage and Separated Overland Flow Area Datasets in the Camp Keais Strand MIKE SHE Model.

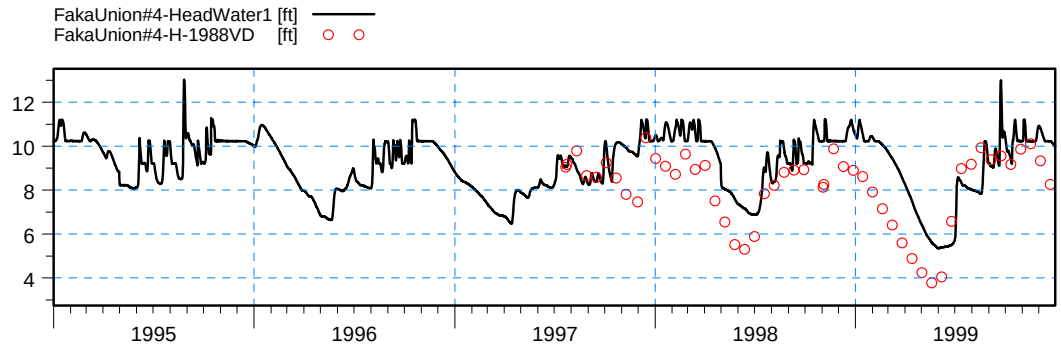

Figure 3.10 Simulated and Observed Results at the Faka Union Canal Number 4 Headwater Gage.

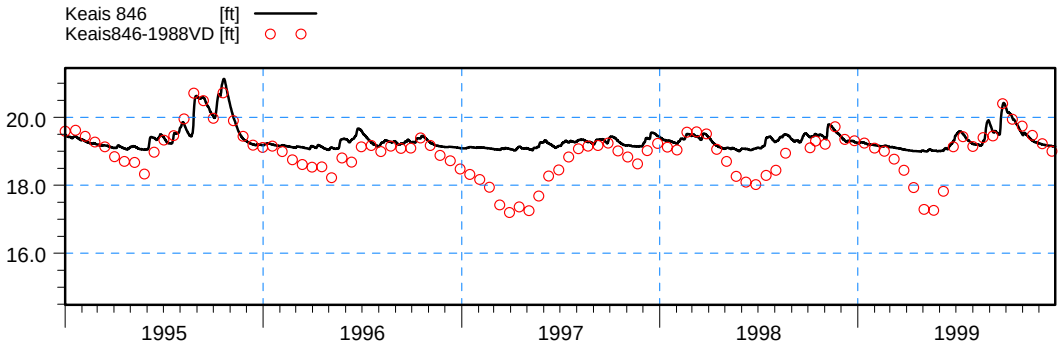

Figure 3.11 Simulated and Observed Results at the Camp Keais Strand on CR 846 Gage.

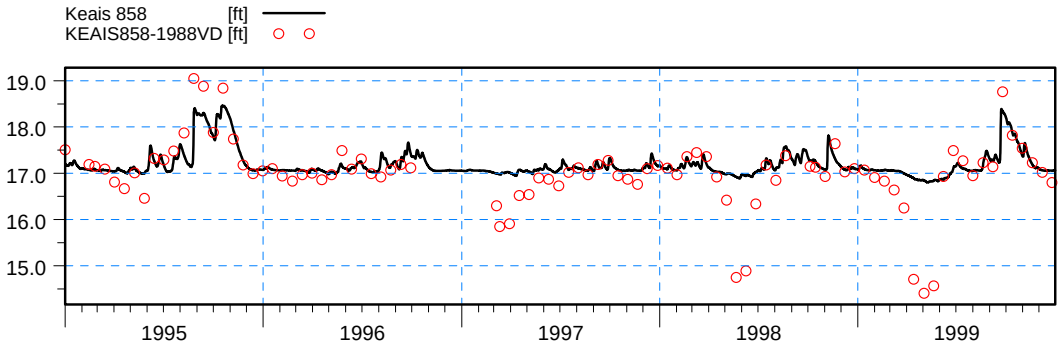

Figure 3.12 Simulated and Observed Results at the Camp Keais Strand on CR 848 Gage.

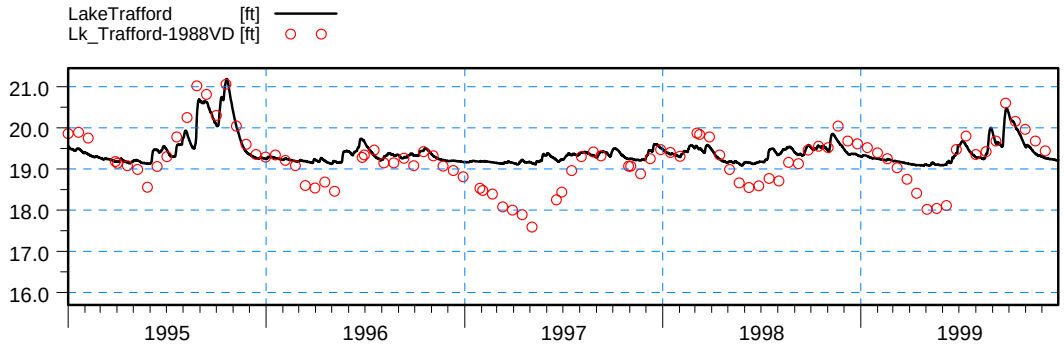

Figure 3.13 Simulated and Observed Results at the Lake Trafford.

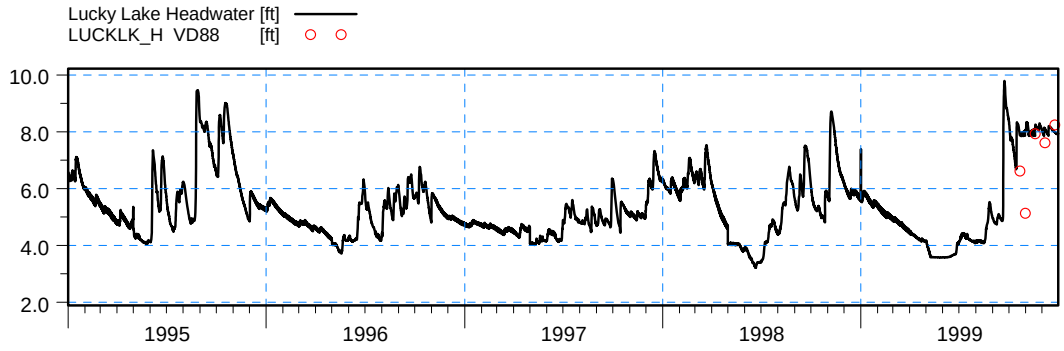

Figure 3.14 Simulated and Observed Results at the Lucky Lake Weir Headwater Gage.

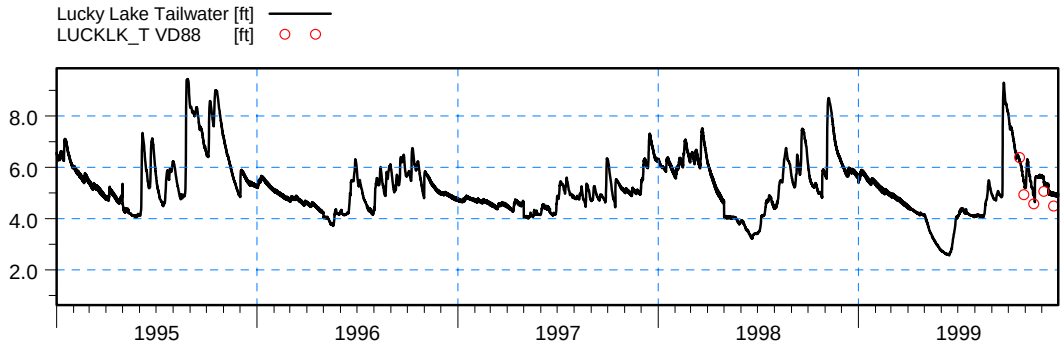

Figure 3.15 Simulated and Observed Results at the Luck Lake Weir Tailwater Gage.

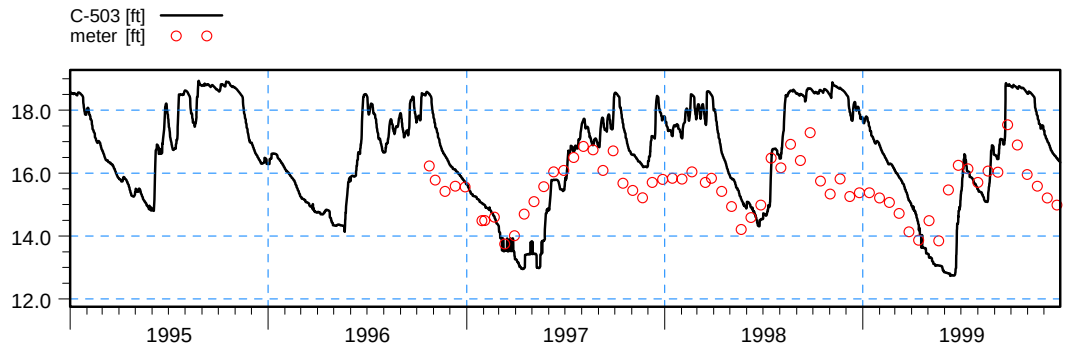

Figure 3.16 Simulated and Observed Results at the Groundwater Observation Well C-503.

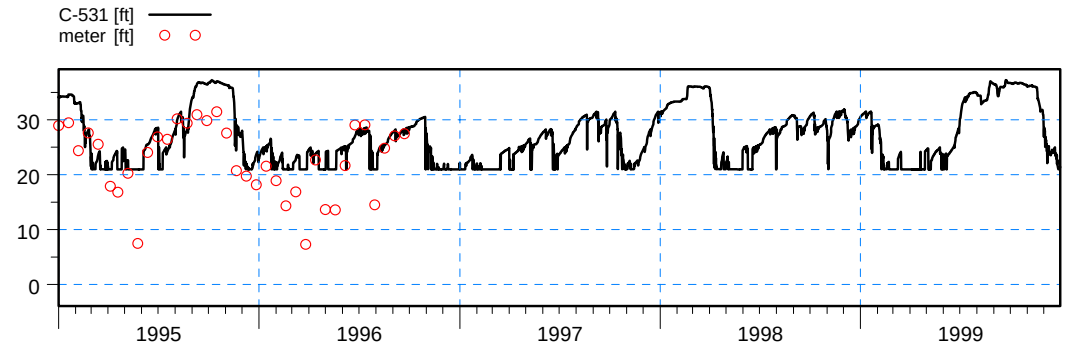

Figure 3.17 Simulated and Observed Results at the Groundwater Observation Well C-531.

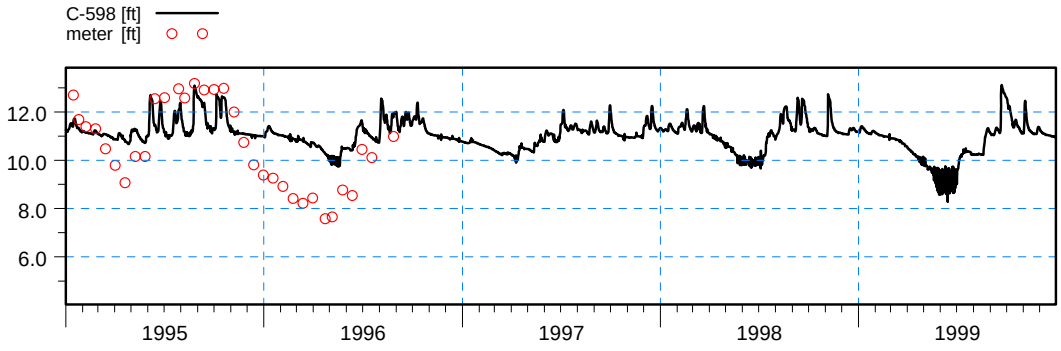

Figure 3.18 Simulated and Observed Results at the Groundwater Observation Well C-598.

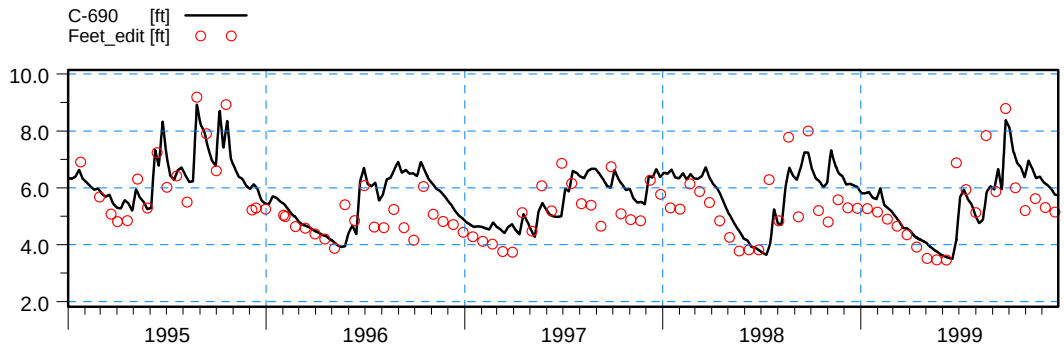

Figure 3.19 Simulated and Observed Results at the Groundwater Observation Well C-690.

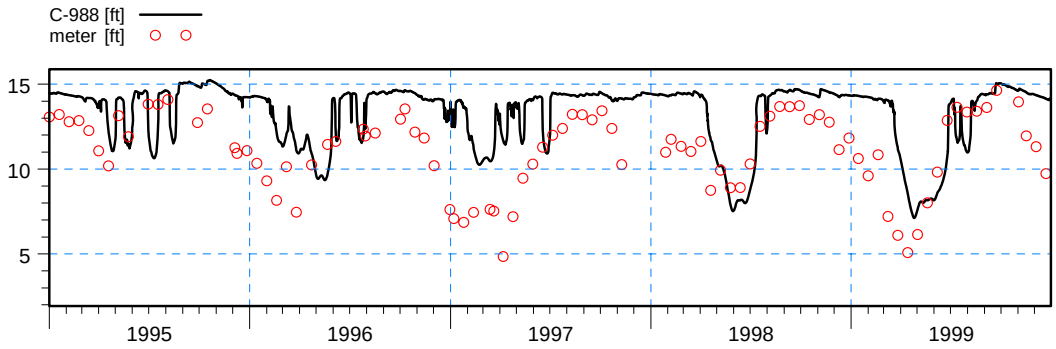

Figure 3.20 Simulated and Observed Results at the Groundwater Observation Well C-988.

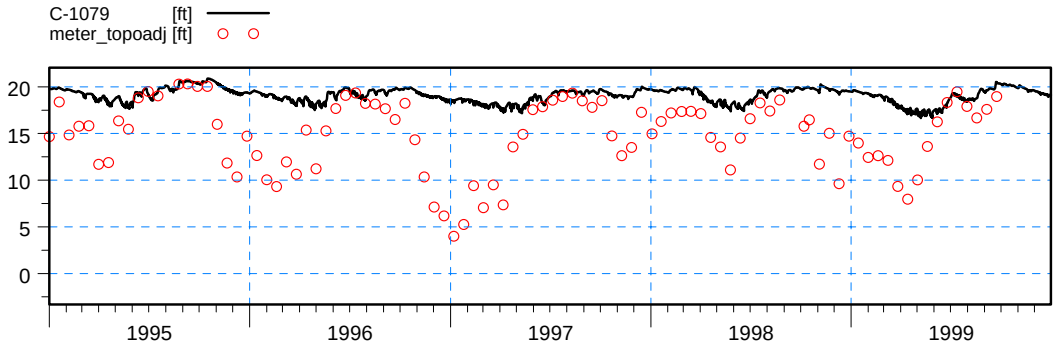

Figure 3.21 Simulated and Observed Results at the Groundwater Observation Well C-1079.

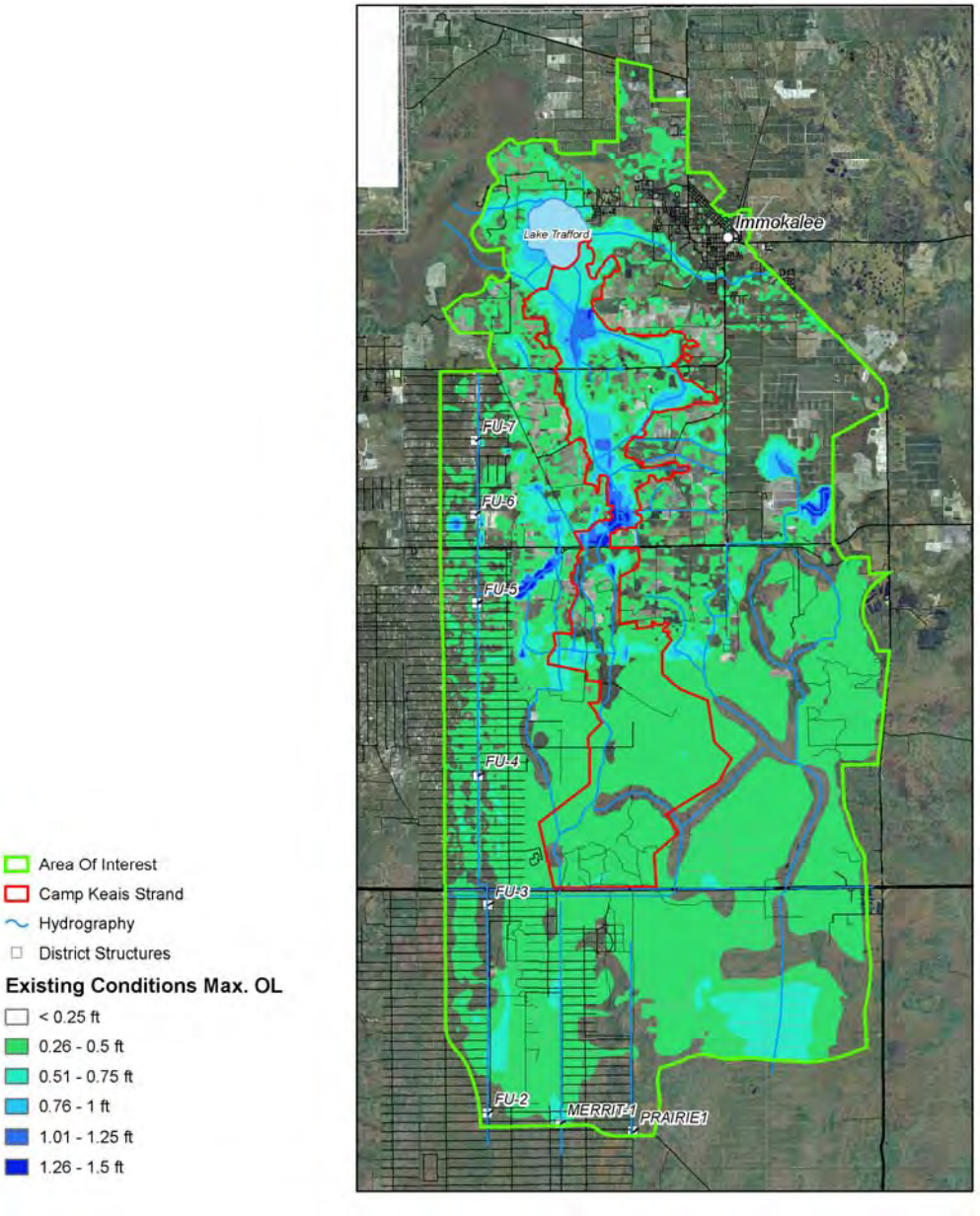

Figure 3.22 Simulated Maximum Overland Water Depths for the Calibrated Model with the 5-day 100-year Design Event.

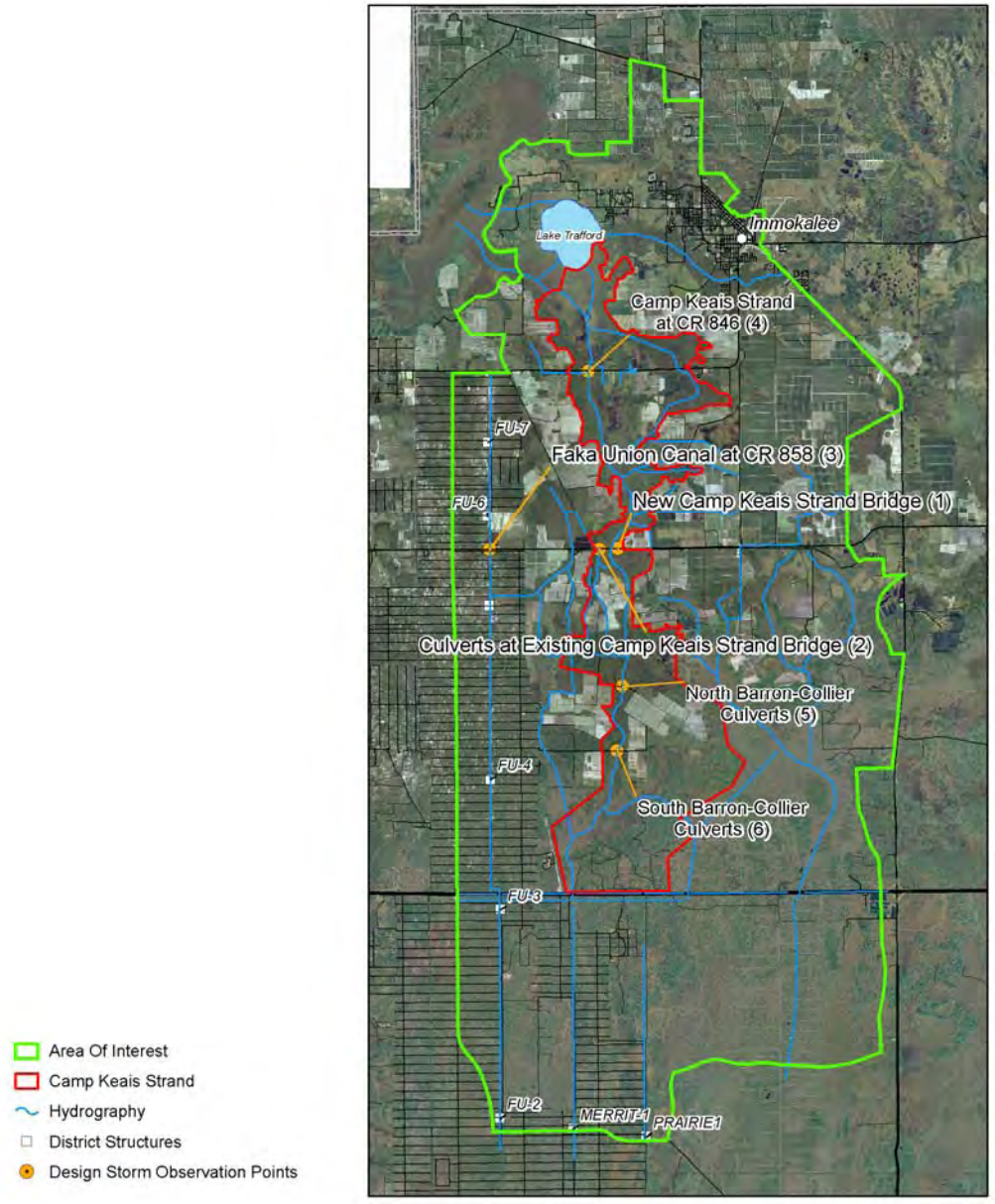

Figure 4.1 Locations Used to Evaluate Simulated Camp Keais Strand Model Scenario Results.

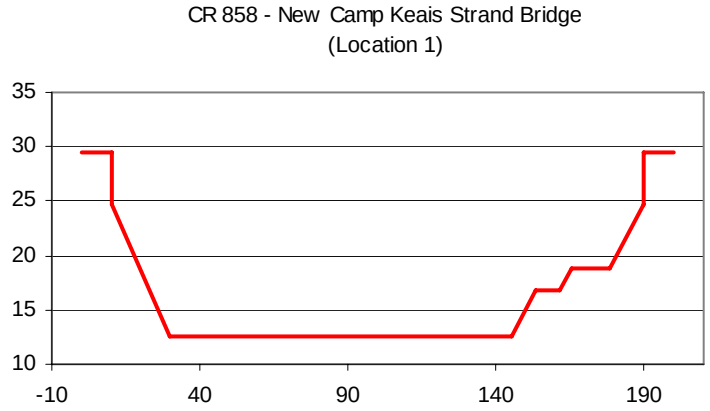

Figure 4.2 Geometry of the New Bridge on CR-858 at Camp Keais Strand (Location 1). View Looking North.

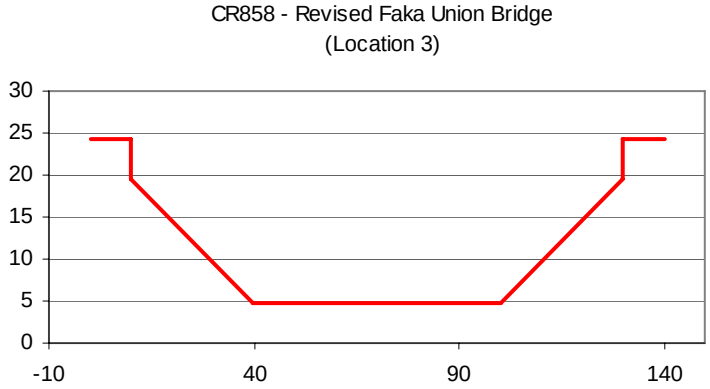

Figure 4.3 Geometry of the Modified Bridge on CR-858 at Faka Union Canal (Location 3). View Looking North.

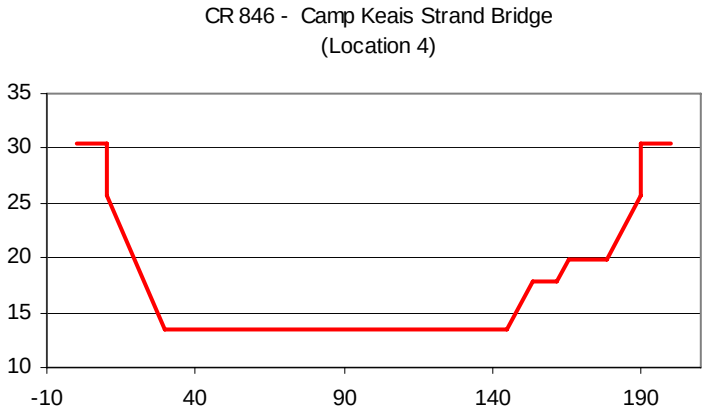

Figure 4.4 Geometry of the New Bridge on CR-846 at Camp Keais Strand (Location 4). View Looking North.

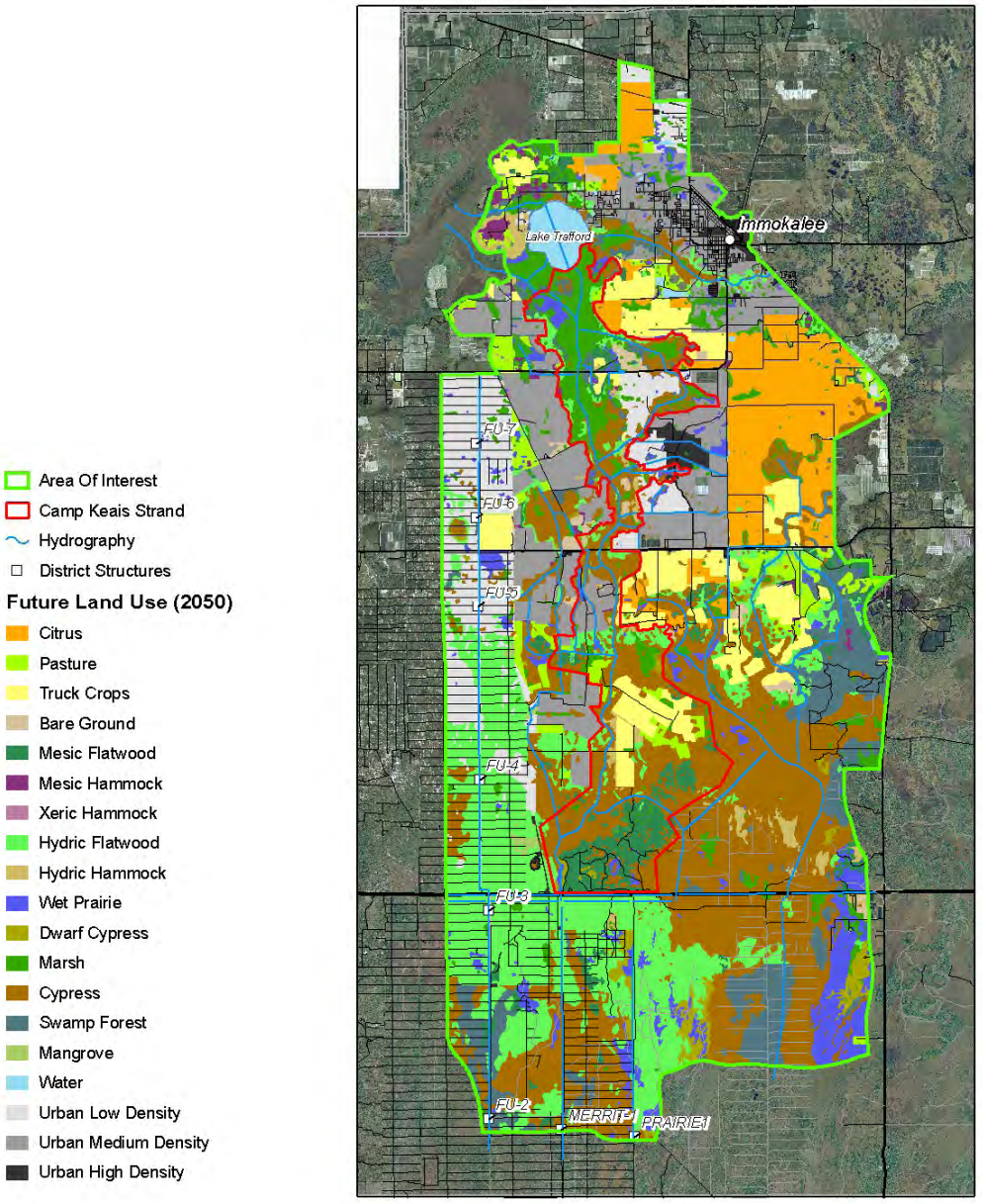

Figure 4.5 2050 Land-Use Data for the Camp Keais Strand Area.

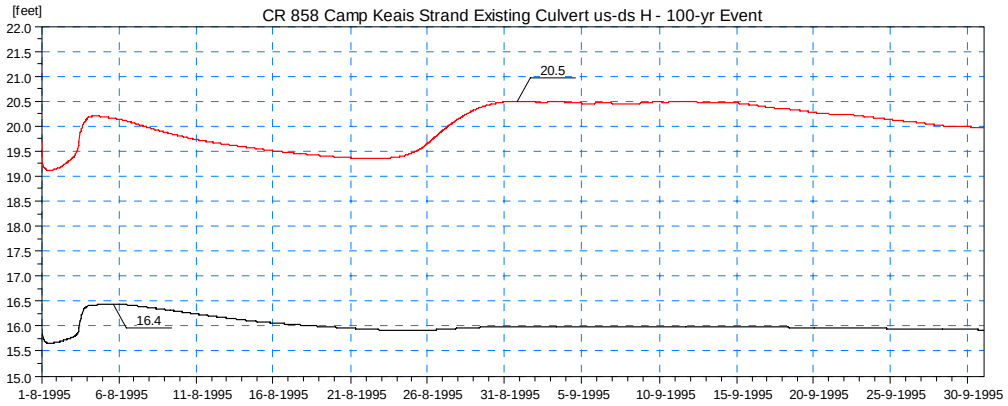

Figure 4.6 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream (red) and Downstream (black) of the Existing Culvert on CR-858 at Camp Keais Strand (Location 1) for the 100-year Design Event.

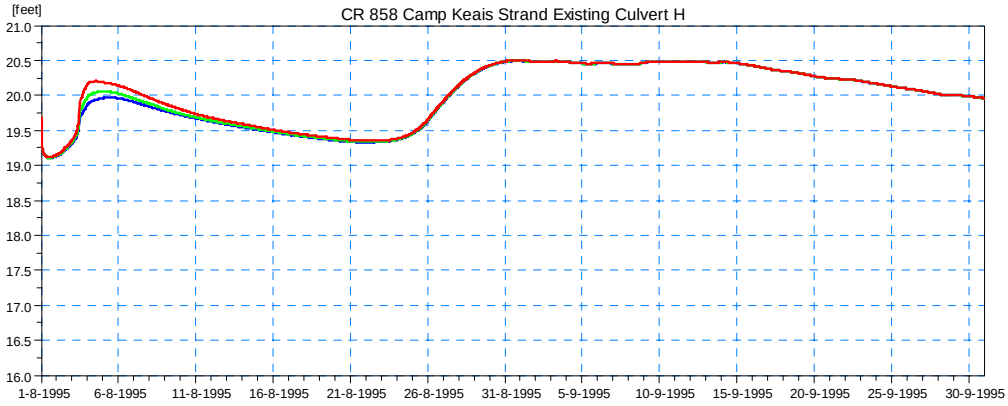

Figure 4.7 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream of the Existing Culvert on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

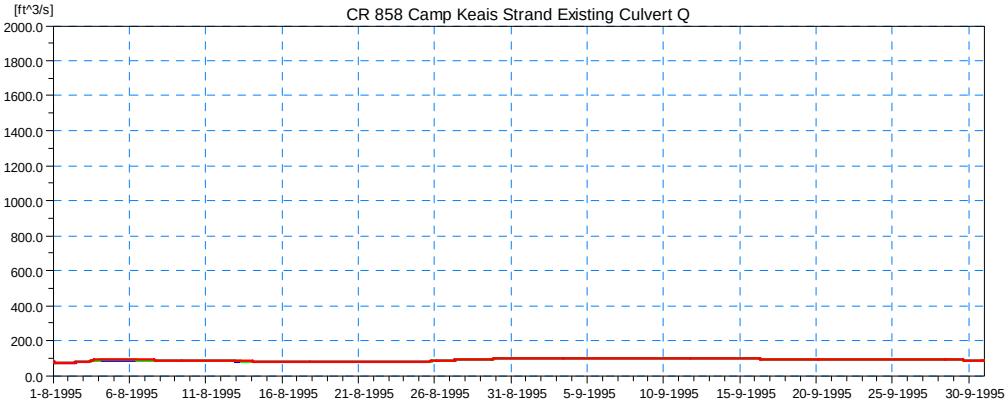

Figure 4.8 Simulated Discharge Results for Existing Conditions (Scenario 0) at the Existing Culvert on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

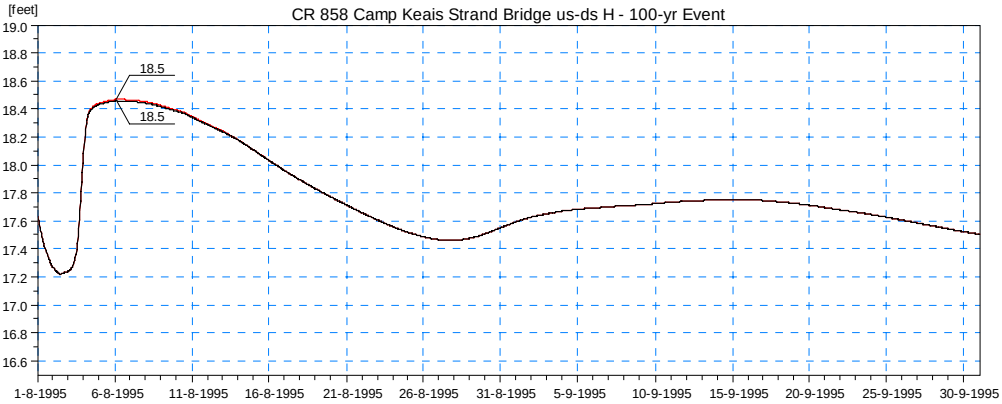

Figure 4.9 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream (red) and Downstream (black) of the Existing Bridge on CR-858 at Camp Keais Strand (Location 2) for the 100-year Design Event.

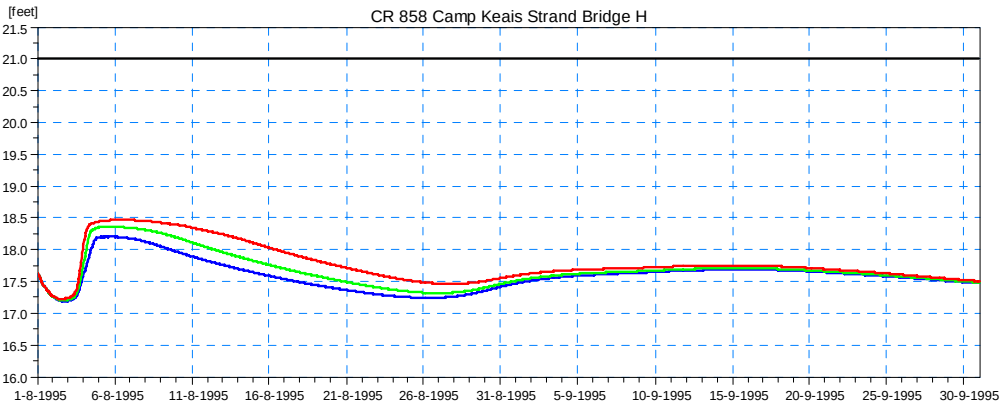

Figure 4.10 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream of the Existing Bridge on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

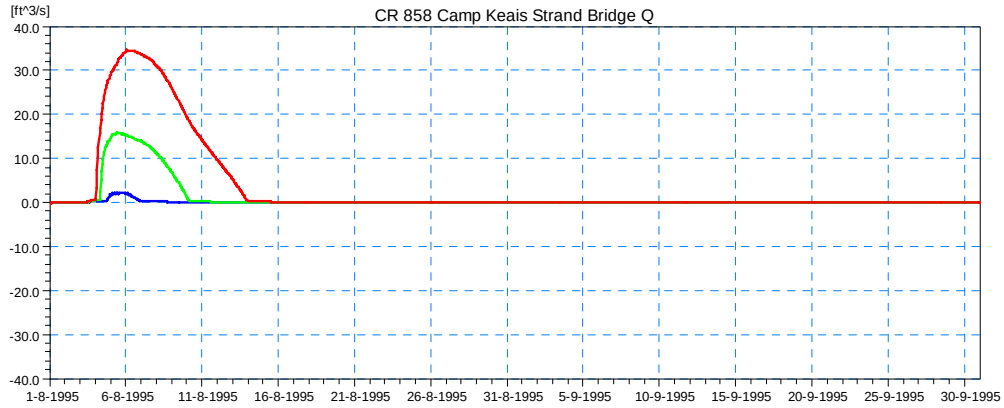

Figure 4.11 Simulated Discharge Results for Existing Conditions (Scenario 0) at the Existing Bridge on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

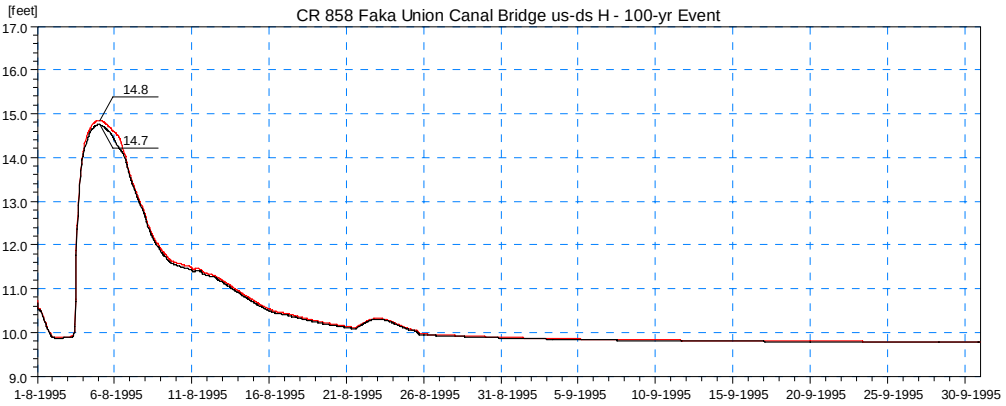

Figure 4.12 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream (red) and Downstream (black) of the Existing Bridge on CR-858 at Faka Union Canal (Location 3) for the 100-year Design Event.

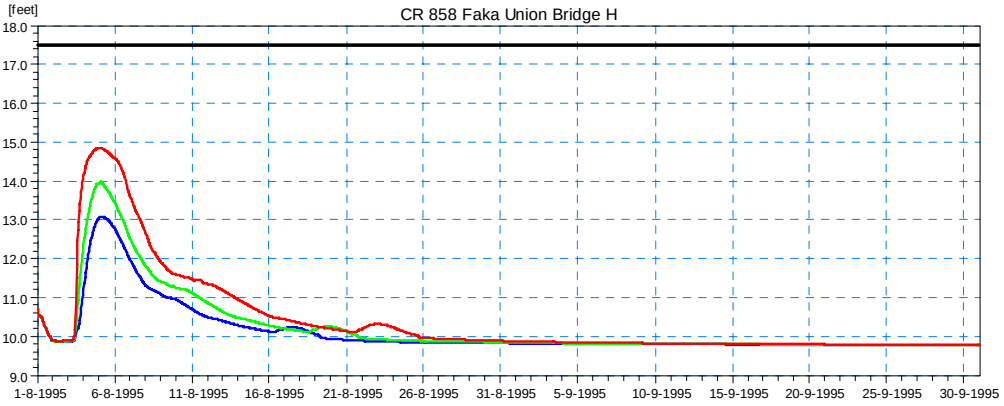

Figure 4.13 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream of the Existing Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

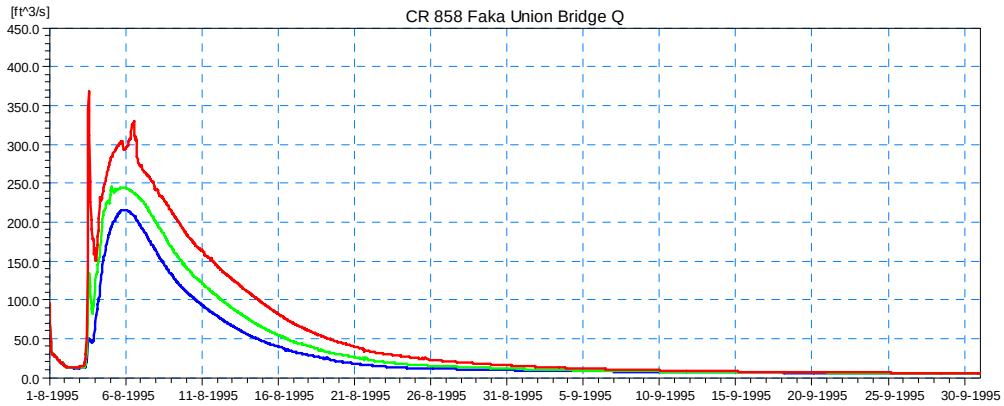

Figure 4.14 Simulated discharge results for existing conditions (Scenario 0) at the existing bridge on CR-858 at Faka Union Canal (location 3) for the 5-year (blue), 25-year (green), and 100-year (red) design event.

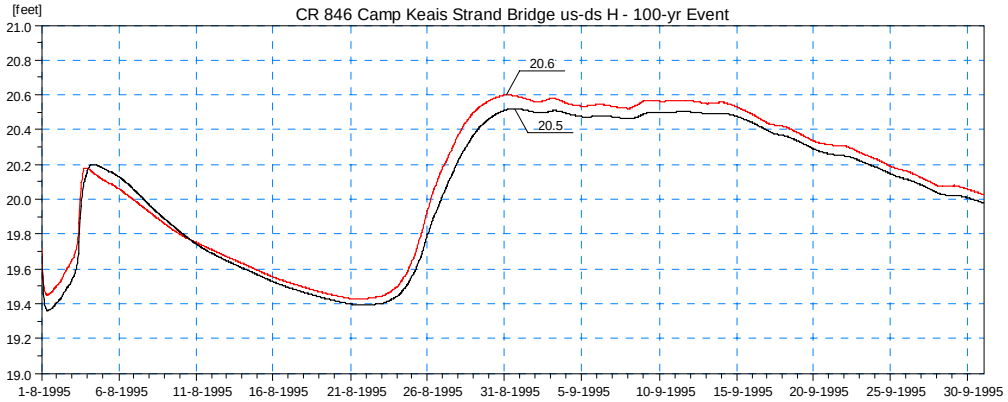

Figure 4.15 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream (red) and Downstream (black) of the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 100-year Design Event.

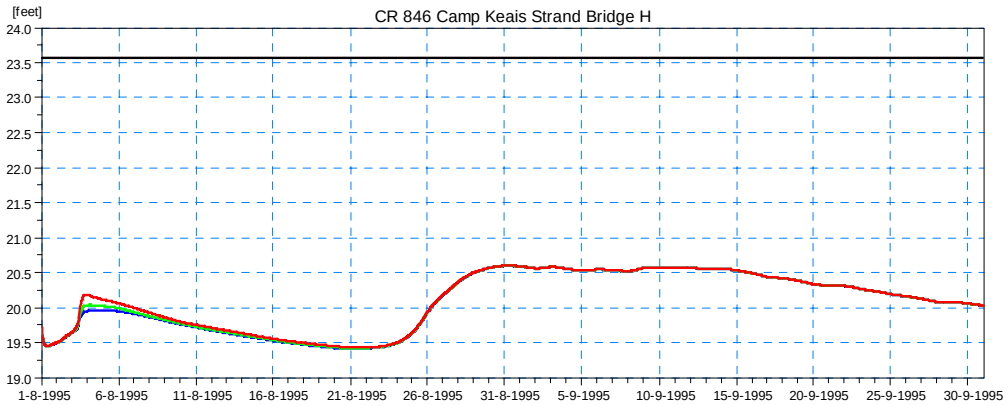

Figure 4.16 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream of the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

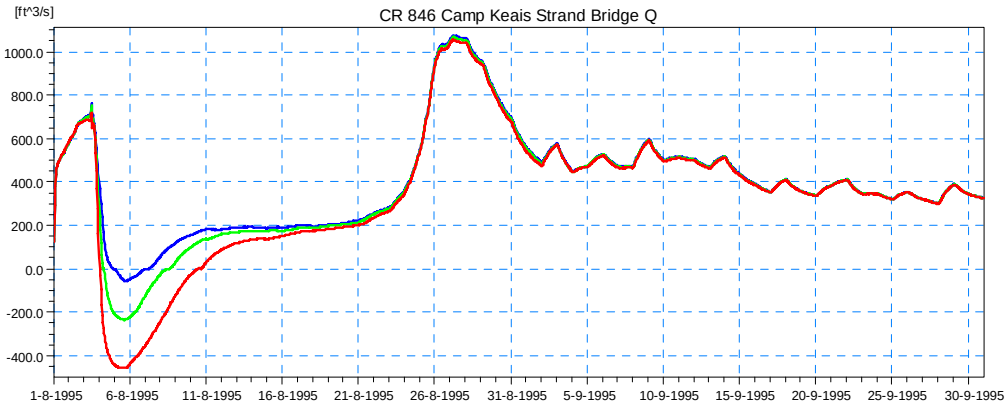

Figure 4.17 Simulated Discharge Results for Existing Conditions (Scenario 0) at the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

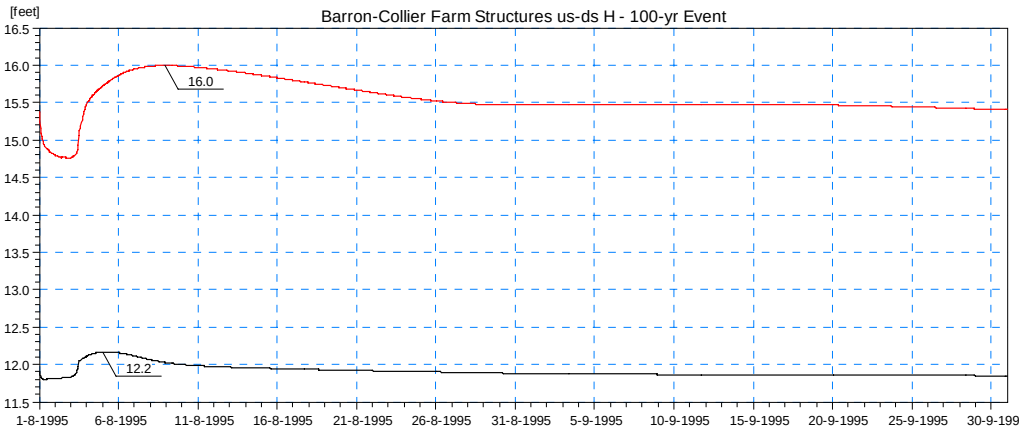

Figure 4.18 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream (red) and Downstream (black) of the Existing Barron-Collier Structures in Camp Keais Strand (Locations 5 and 6) for the 100-year Design Event.

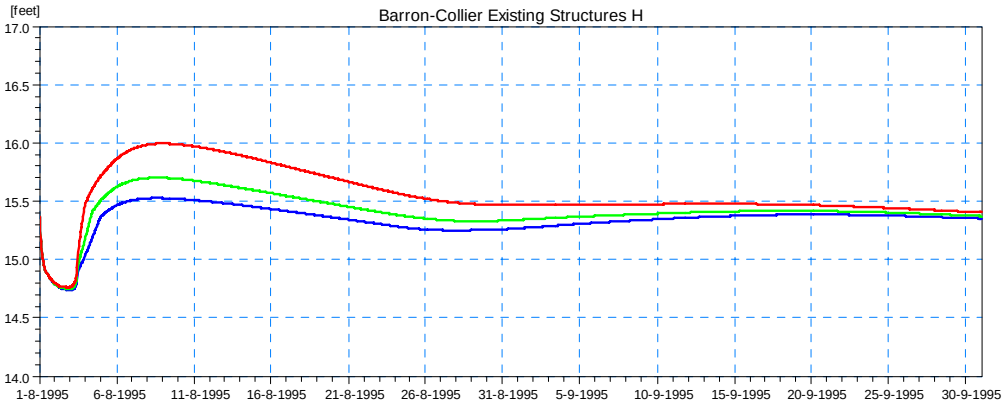

Figure 4.19 Simulated Stage Results for Existing Conditions (Scenario 0) Upstream of the Existing Barron-Collier Structure in Camp Keais Strand (Location 5) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

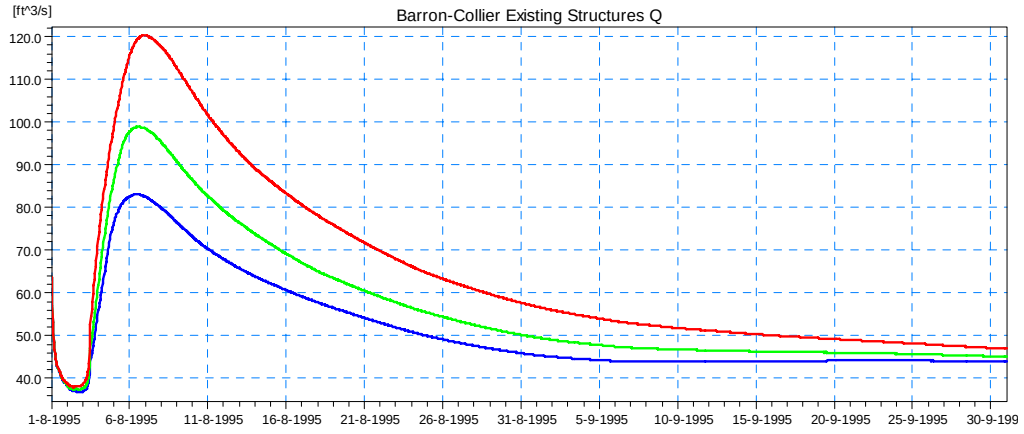

Figure 4.20 Simulated Discharge results for Existing Conditions (Scenario 0) at the Existing Barron-Collier Structure in Camp Keais Strand (Location 6) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

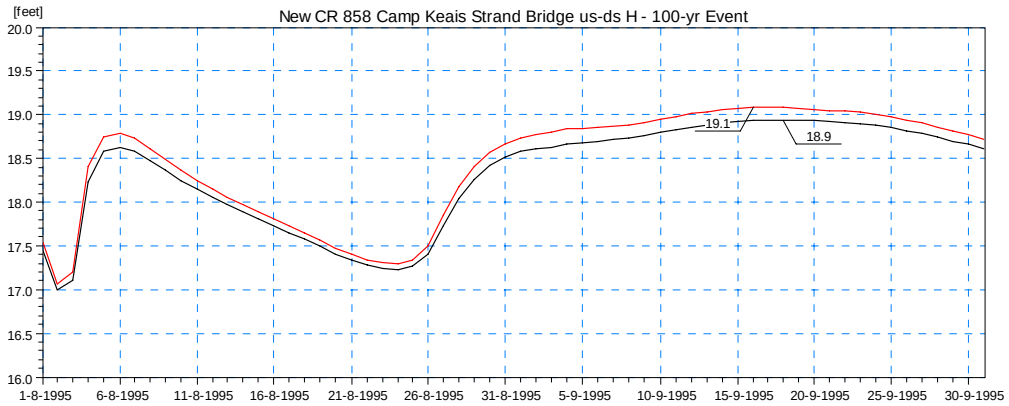

Figure 4.21 Simulated Stage Results for Scenario 1 Upstream (red) and Downstream (black) of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 100-year Design Event.

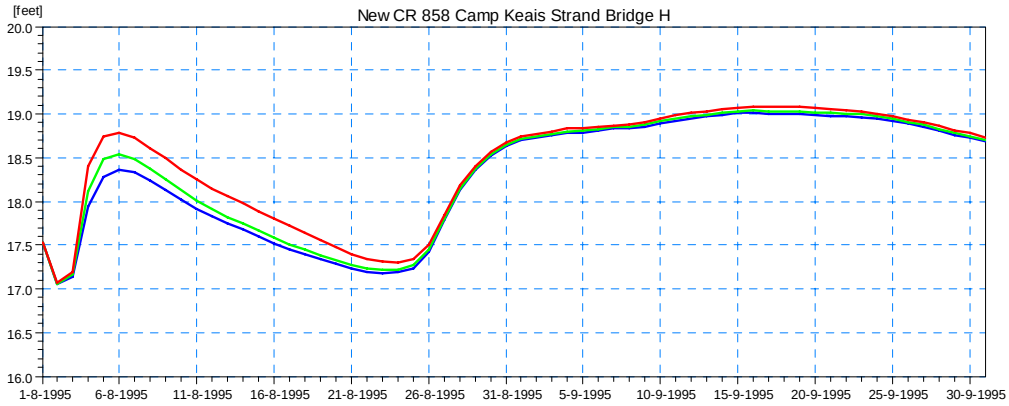

Figure 4.22 Simulated Stage Results for Scenario 1 Upstream of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

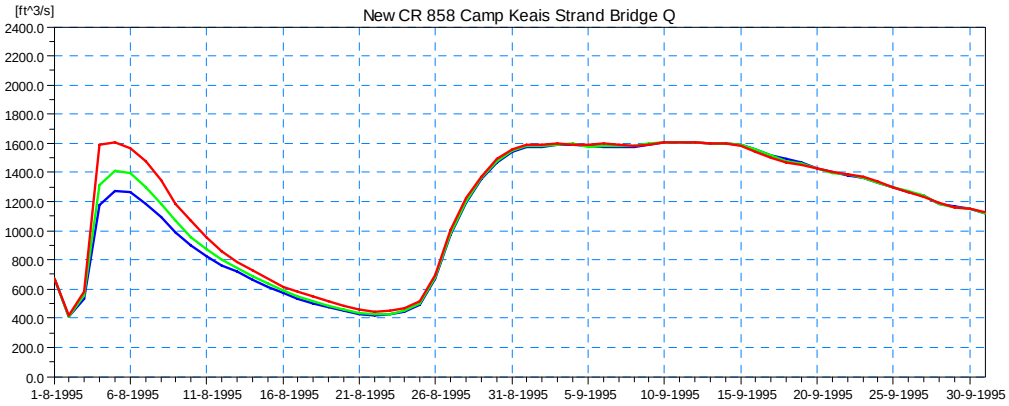

Figure 4.23 Simulated Discharge Results for Scenario 1 at the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

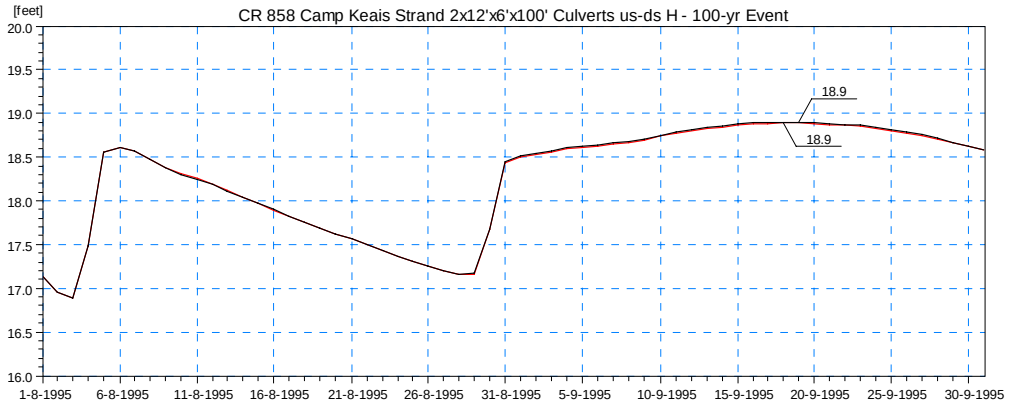

Figure 4.24 Simulated Stage Results for Scenario 1 Upstream (red) and Downstream (black) of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 100-year Design Event.

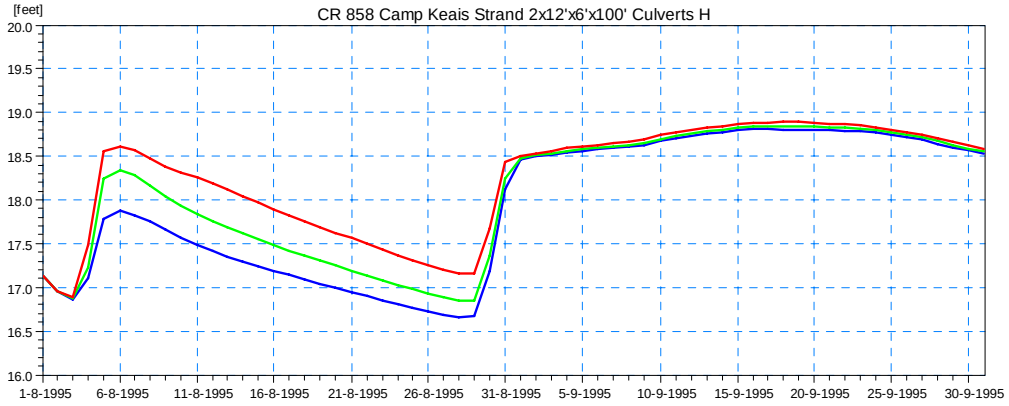

Figure 4.25 Simulated Stage Results for Scenario 1 Upstream of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

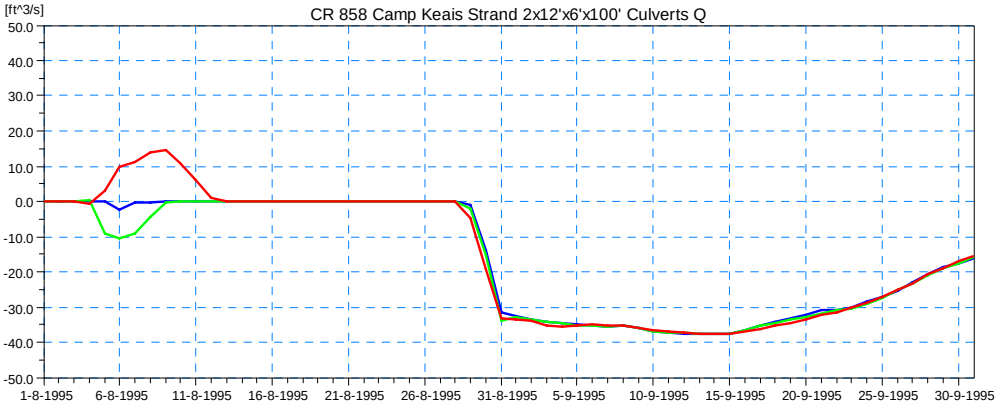

Figure 4.26 Simulated Discharge Results for Scenario 1 at the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

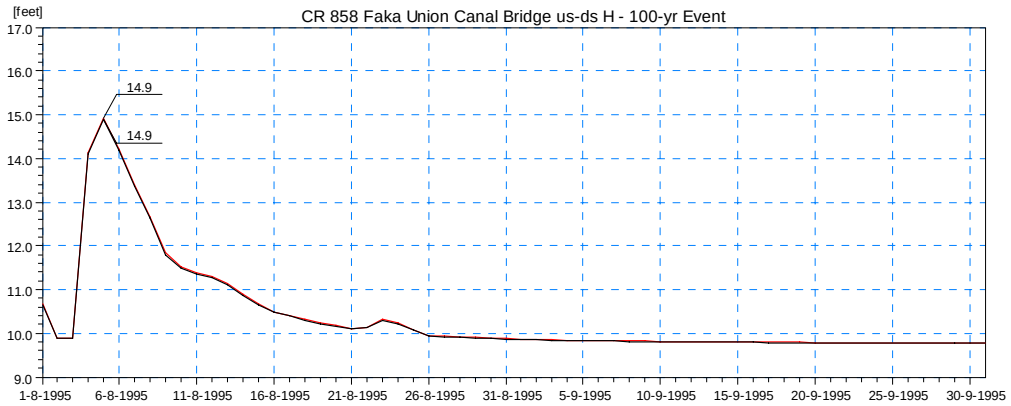

Figure 4.27 Simulated Stage Results for Scenario 1 Upstream (red) and Downstream (black) of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 100-year Design Event.

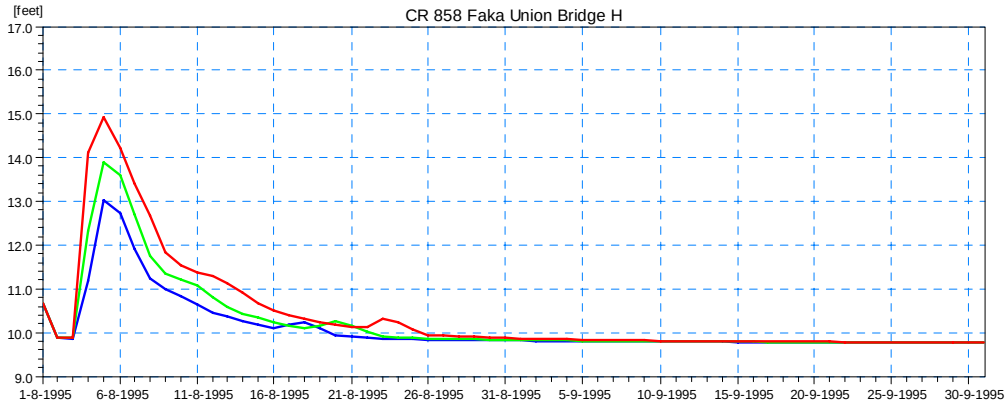

Figure 4.28 Simulated Stage Results for Scenario 1 Upstream of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

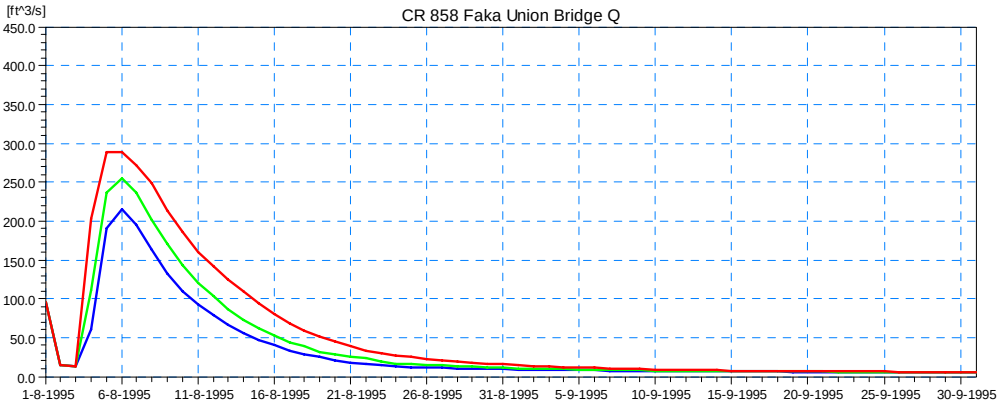

Figure 4.29 Simulated Discharge Results for Scenario 1 at the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

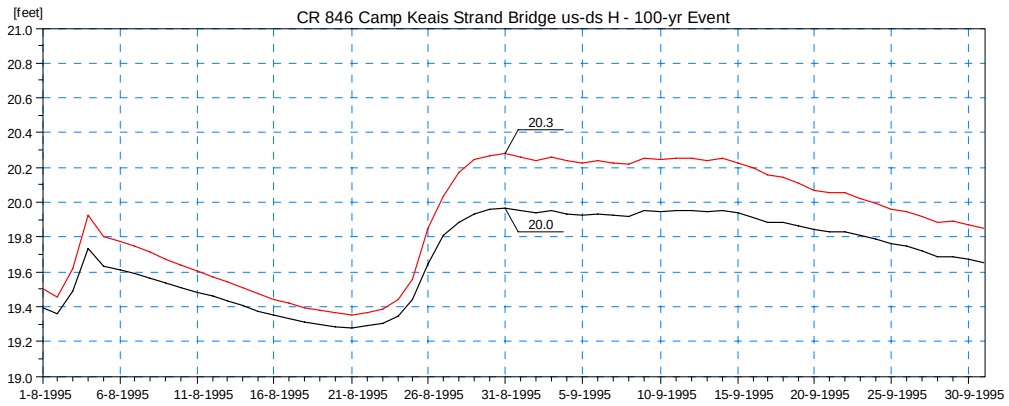

Figure 4.30 Simulated Stage Results for Scenario 1 Upstream (red) and Downstream (black) of the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 100-year Design Event.

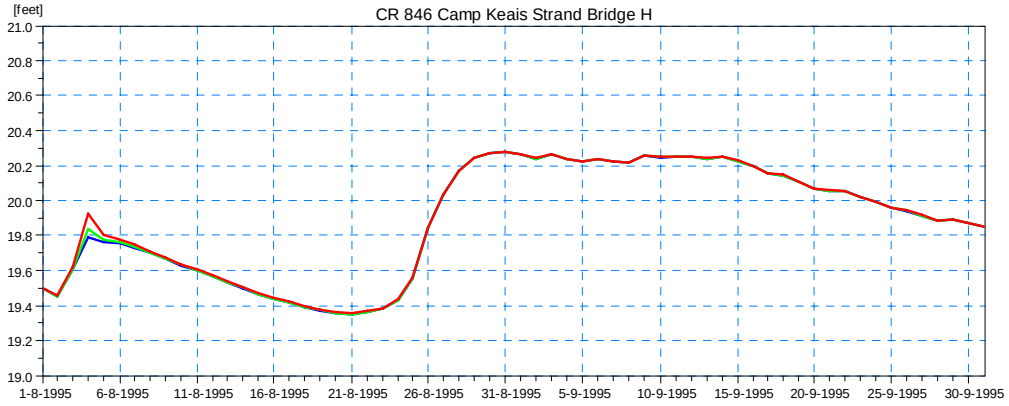

Figure 4.31 Simulated Stage Results for Scenario 1 Upstream of the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

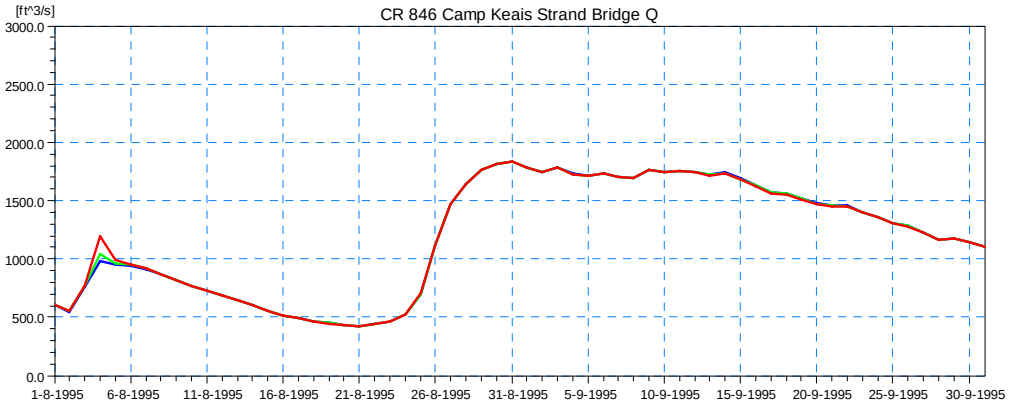

Figure 4.32 Simulated Discharge Results for Scenario 1 at the Existing Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

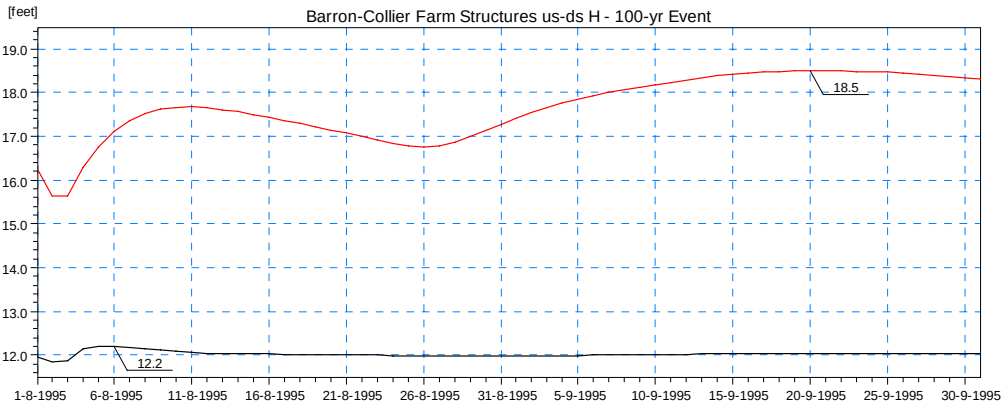

Figure 4.33 Simulated Stage Results for Scenario 1 Upstream (red) and Downstream (black) of the Existing Barron-Collier Structures in Camp Keais Strand (Lcations 5 and 6) for the 100-year Design Event.

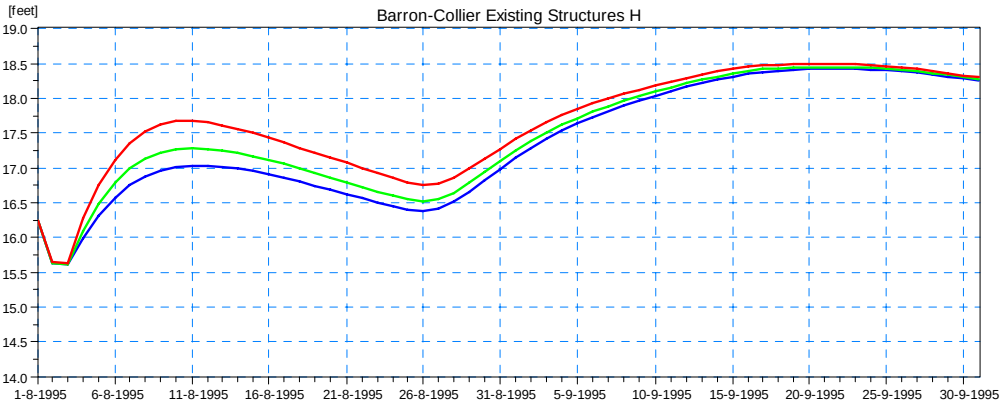

Figure 4.34 Simulated Stage Results for Scenario 1 Upstream of the Existing Barron-Collier Structure in Camp Keais Strand (Location 5) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

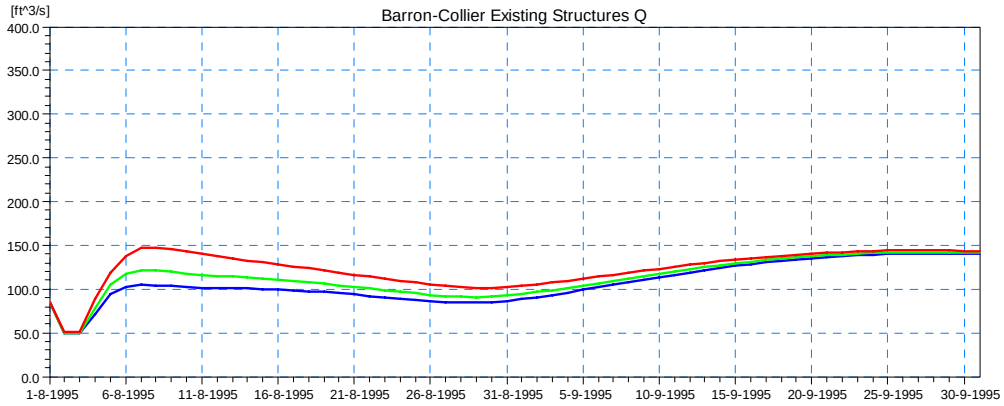

Figure 4.35 Simulated Discharge Results for Scenario 1 at the Existing Barron-Collier Structure in Camp Keais Strand (Location 6) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

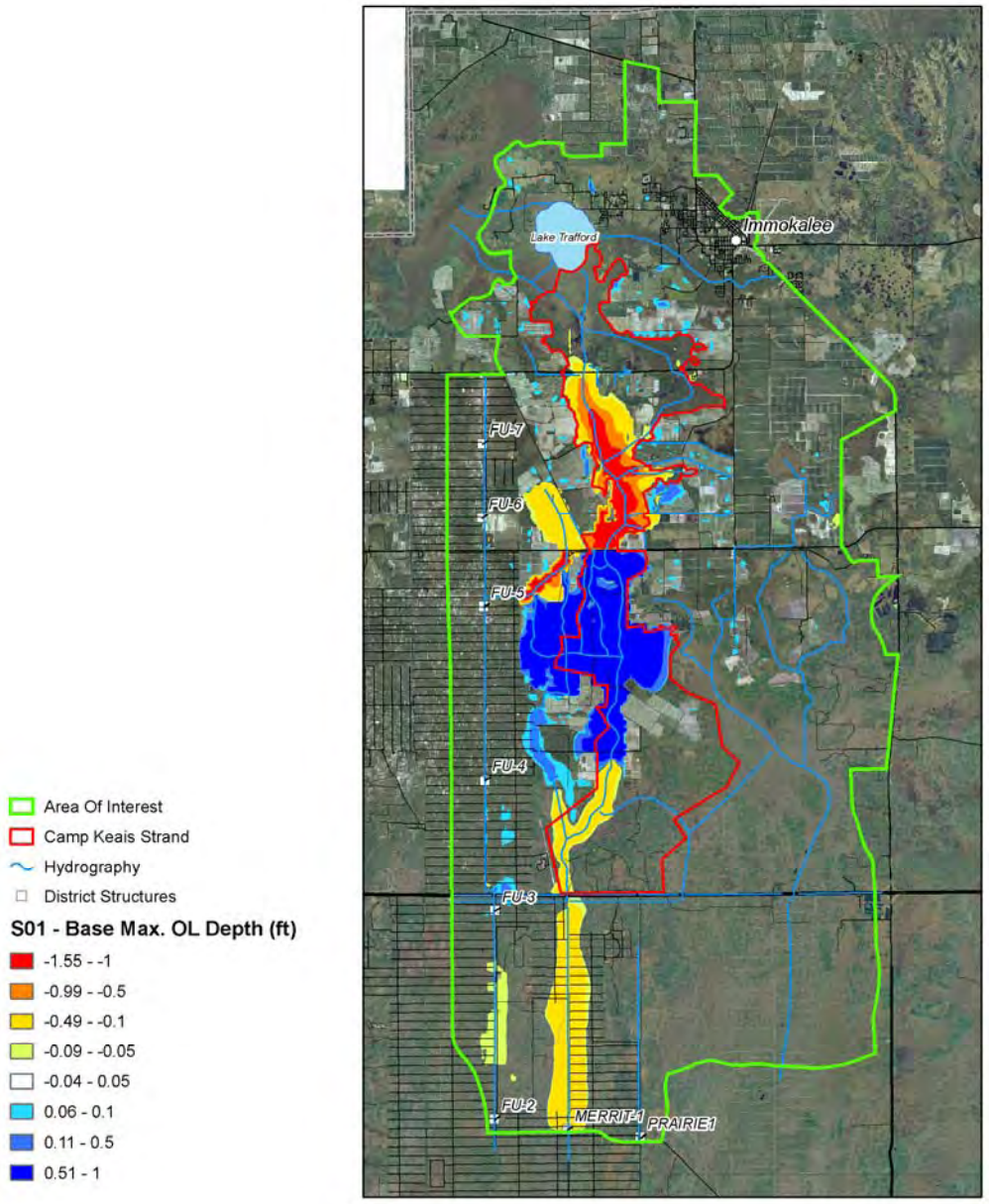

Figure 4.36 Simulated Differences Between Existing Conditions (Scenario 0) and Scenario 1 Maximum Overland Water Depths During the 100-year Design Event.

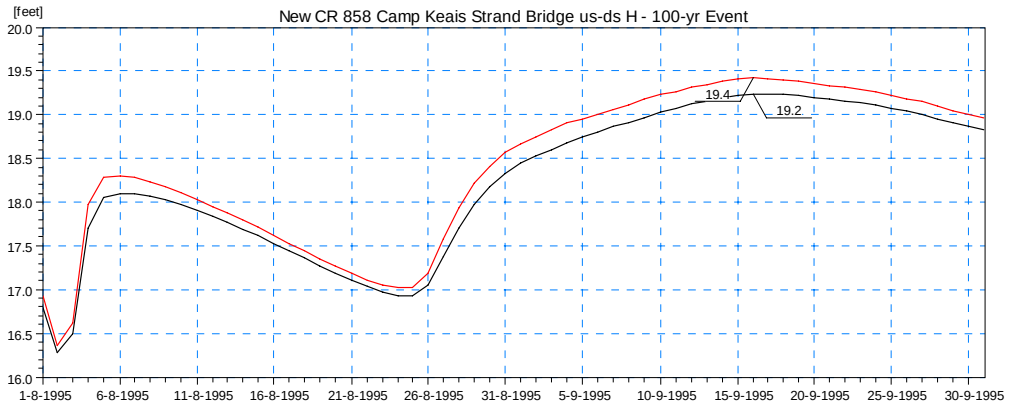

Figure 4.37 Simulated Stage Results for Scenario 2 Upstream (red) and Downstream (black) of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 100-year Design Event.

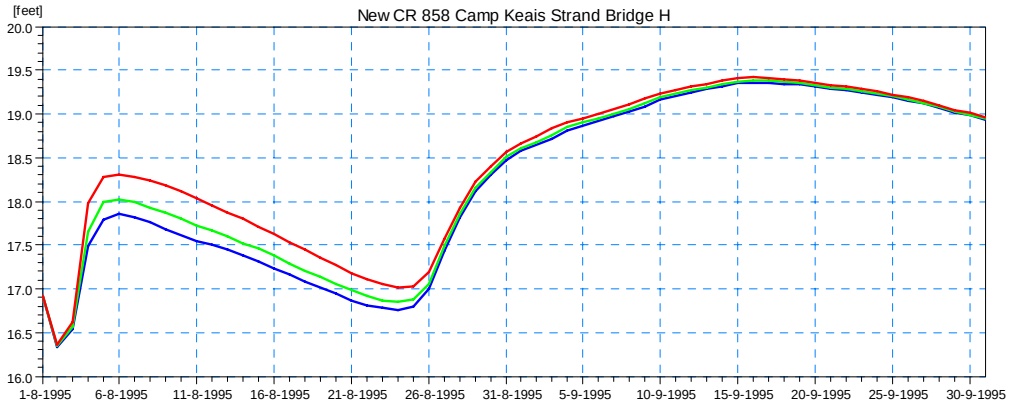

Figure 4.38 Simulated Stage Results for Scenario 2 Upstream of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

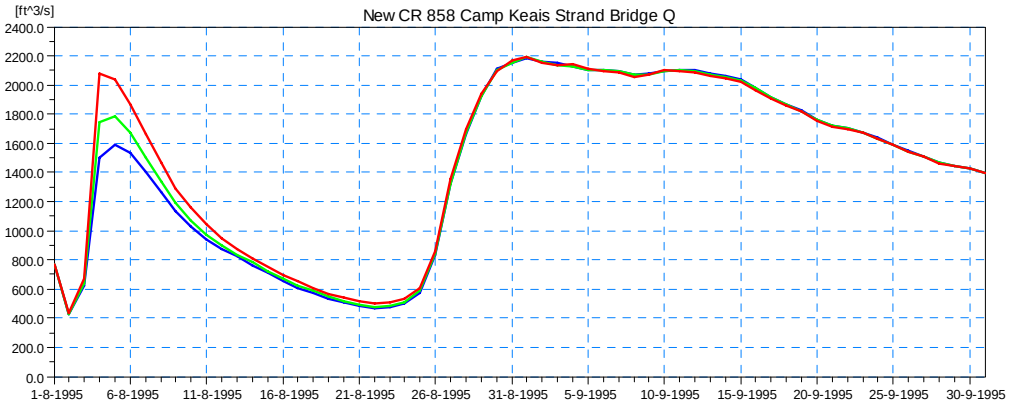

Figure 4.39 Simulated Discharge Results for Scenario 2 at the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

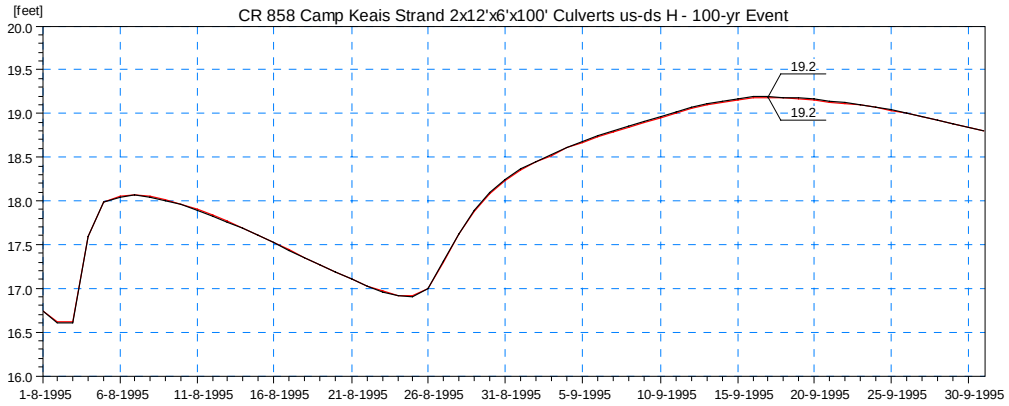

Figure 4.40 Simulated Stage Results for Scenario 2 Upstream (red) and Downstream (Black) of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 100-year Design Event.

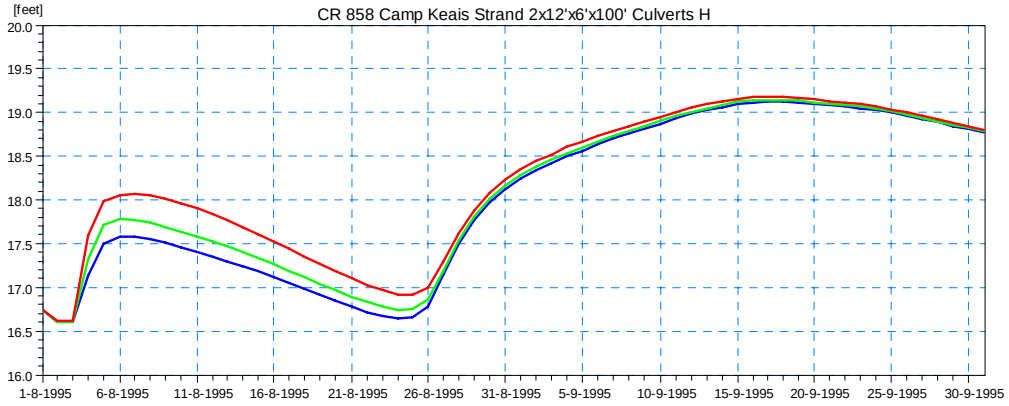

Figure 4.41 Simulated Stage Results for Scenario 2 Upstream of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

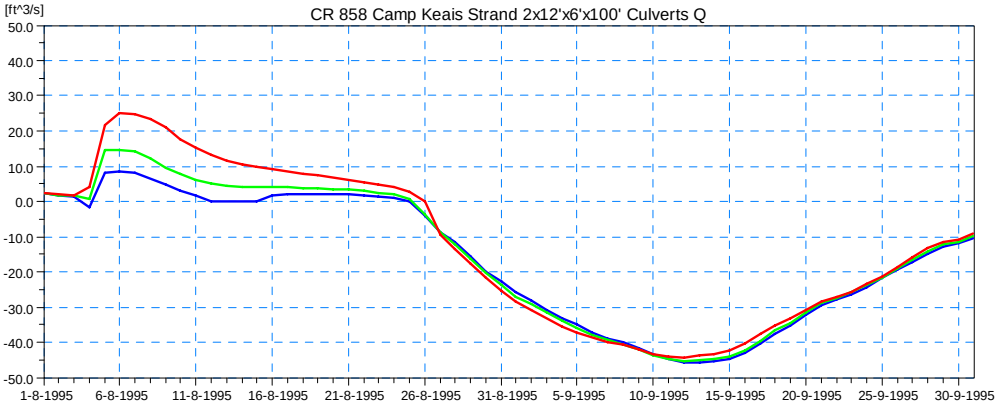

Figure 4.42 Simulated Discharge Results for Scenario 2 at the Proposed Culvert on CR-858 at Camp Keais Strand (lLcation 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

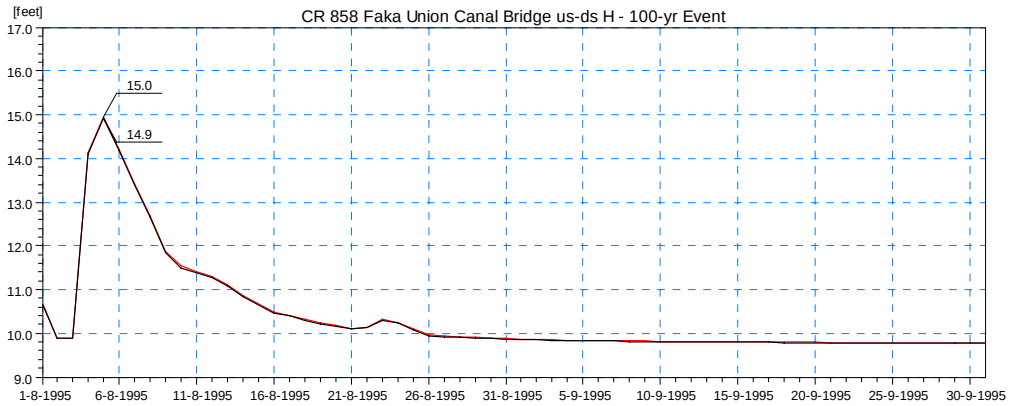

Figure 4.43 Simulated Stage Results for Scenario 2 Upstream (red) and Downstream (black) of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 100-year Design Event.

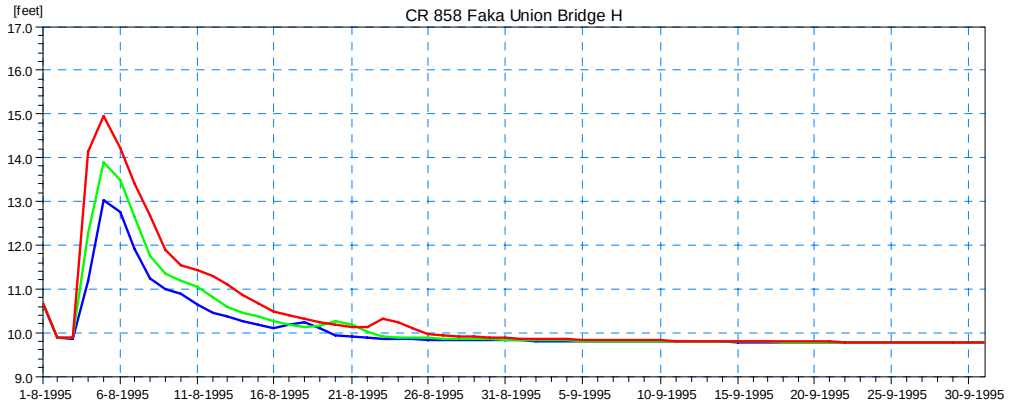

Figure 4.44 Simulated Stage Results for Scenario 2 Upstream of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

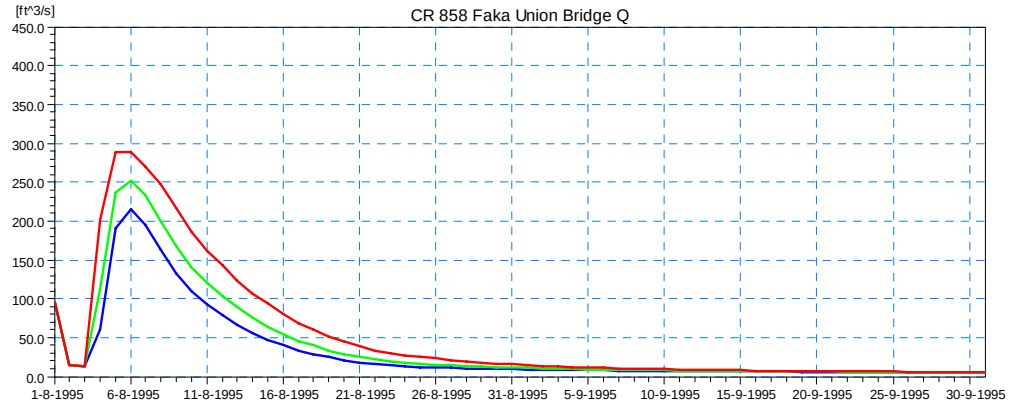

Figure 4.45 Simulated Discharge Results for Scenario 2 at the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

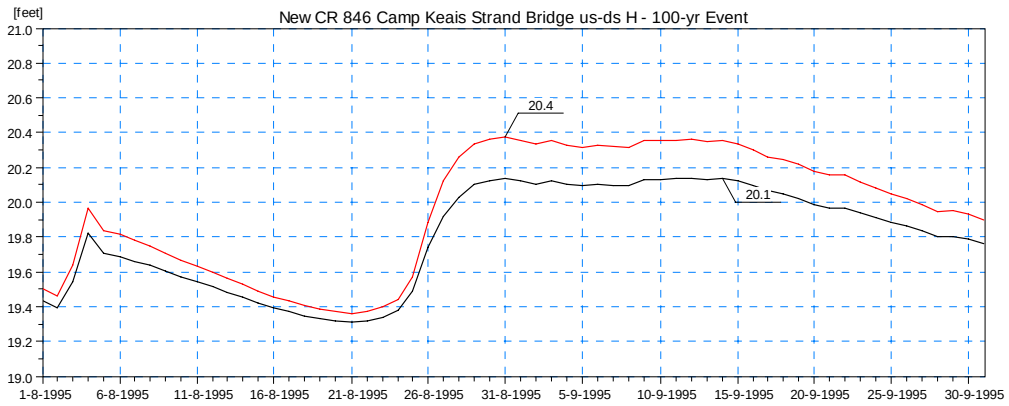

Figure 4.46 Simulated Stage Results for Scenario 2 Upstream (red) and Downstream (black) of the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 100-year Design Event.

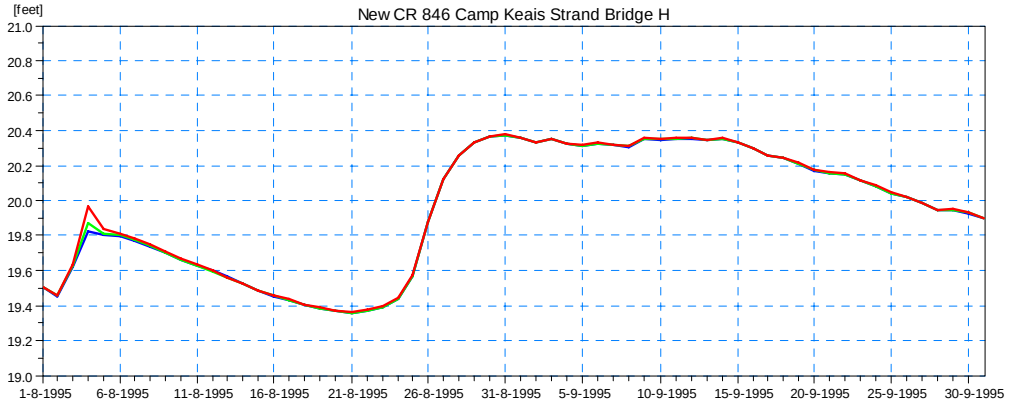

Figure 4.47 Simulated Stage Results for Scenario 2 Upstream of the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

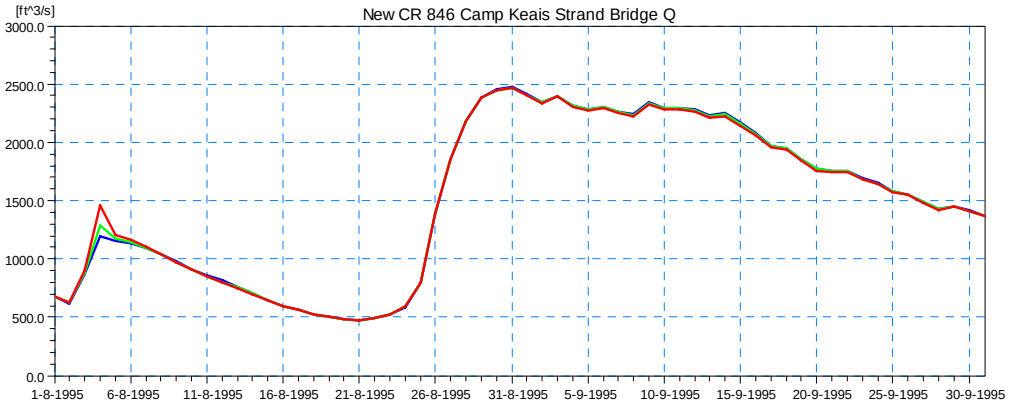

Figure 4.48 Simulated Discharge Results for Scenario 2 at the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

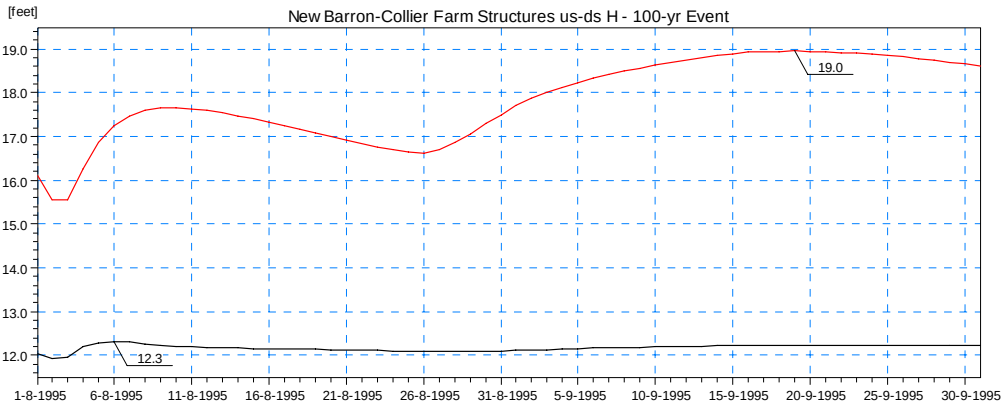

Figure 4.49 Simulated Stage Results for Scenario 2 Upstream (red) and Downstream (black) of the Proposed Modified Barron-Collier Structures in Camp Keais Strand (Locations 5 and 6) for the 100-year Design Event.

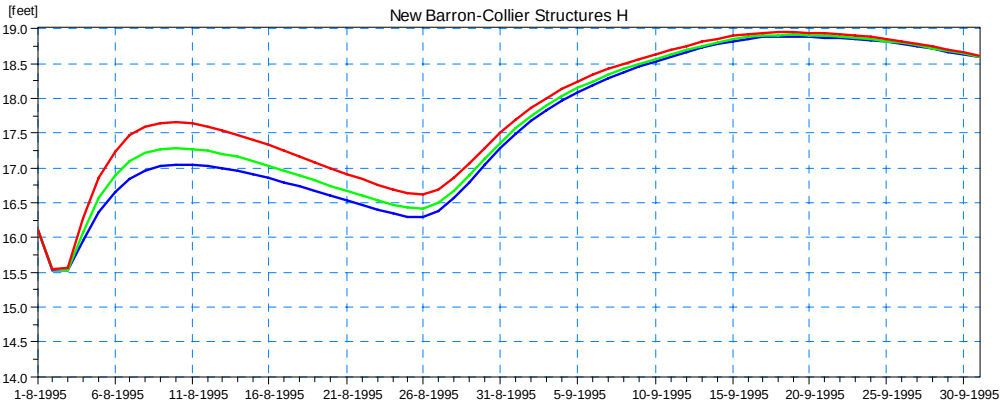

Figure 4.50 Simulated Stage Results for Scenario 2 Upstream of the Proposed Modified Barron-Collier Structure in Camp Keais Strand (Location 5) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

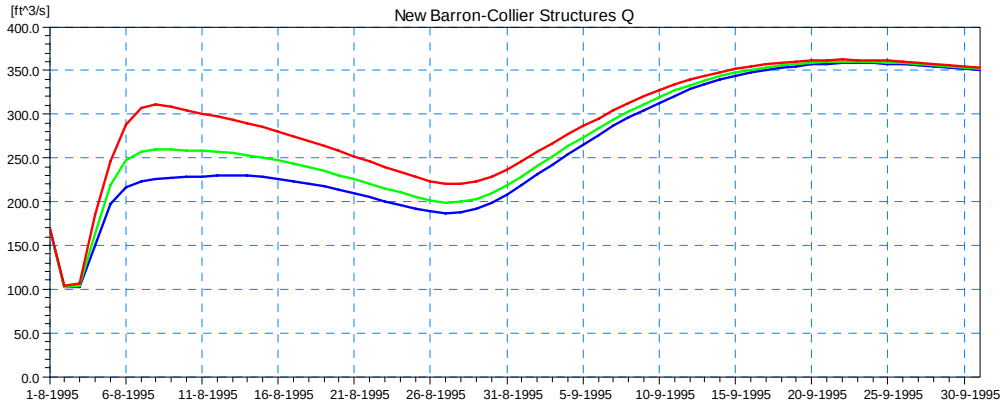

Figure 4.51 Simulated Discharge Results for Scenario 2 at the Proposed Modified Barron-Collier Structure in Camp Keais Strand (Location 6) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

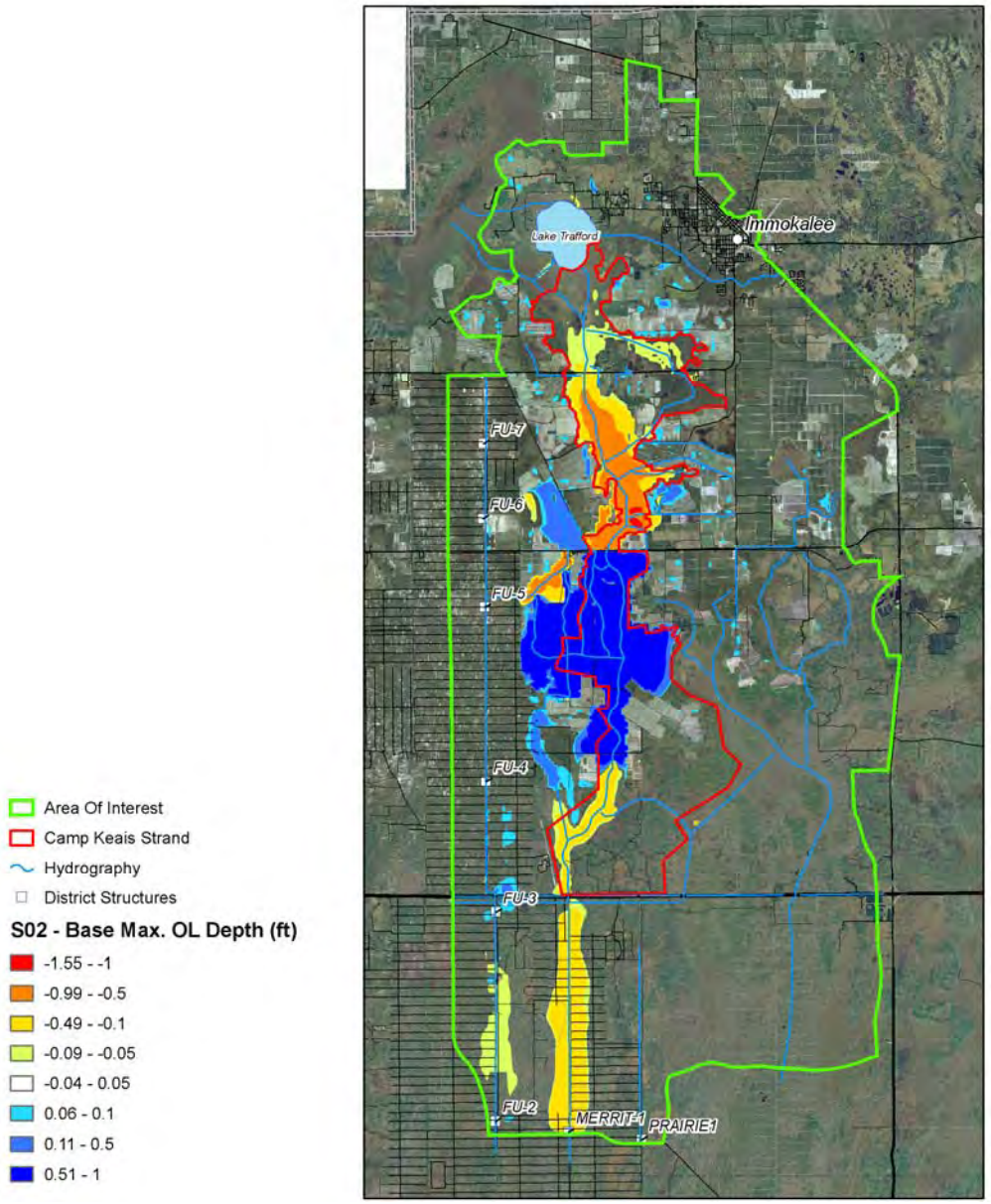

Figure 4.52 Simulated Differences Between Existing Conditions (Scenario 0) and Scenario 2 Maximum Overland Water Depths During the 100-year Design Event.

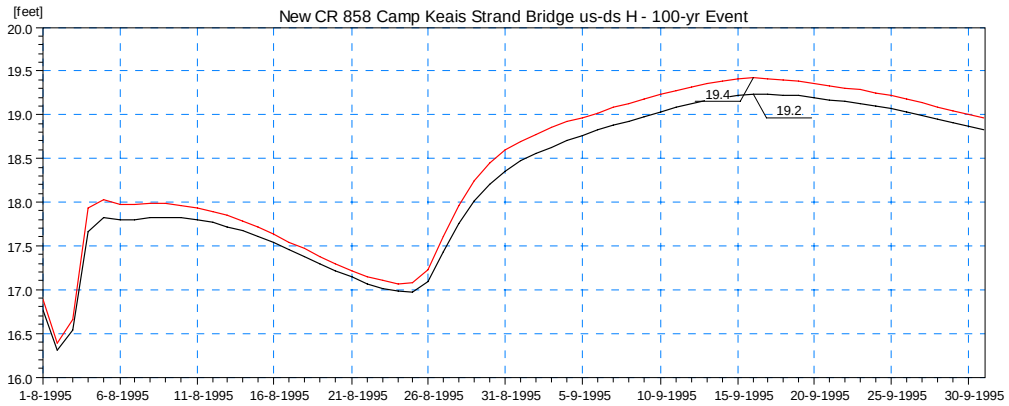

Figure 4.53 Simulated Stage Results for Scenario 3 Upstream (red) and Downstream (black) of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 100-year Design Event.

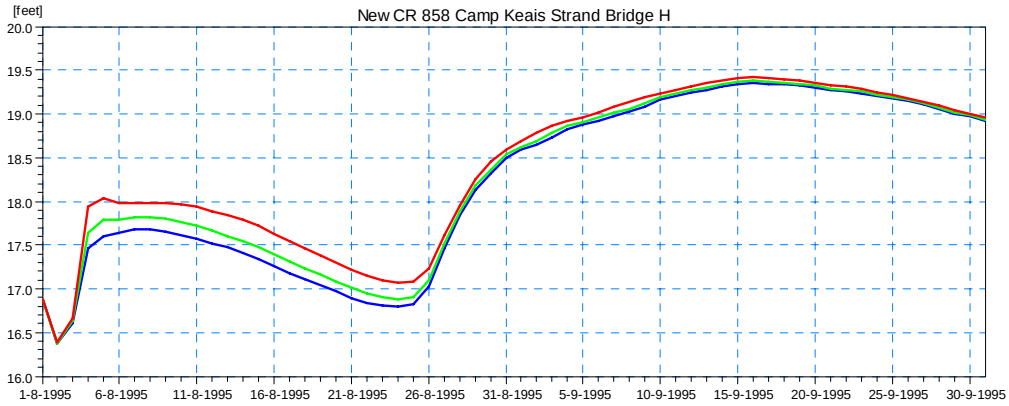

Figure 4.54 Simulated Stage Results for Scenario 3 Upstream of the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

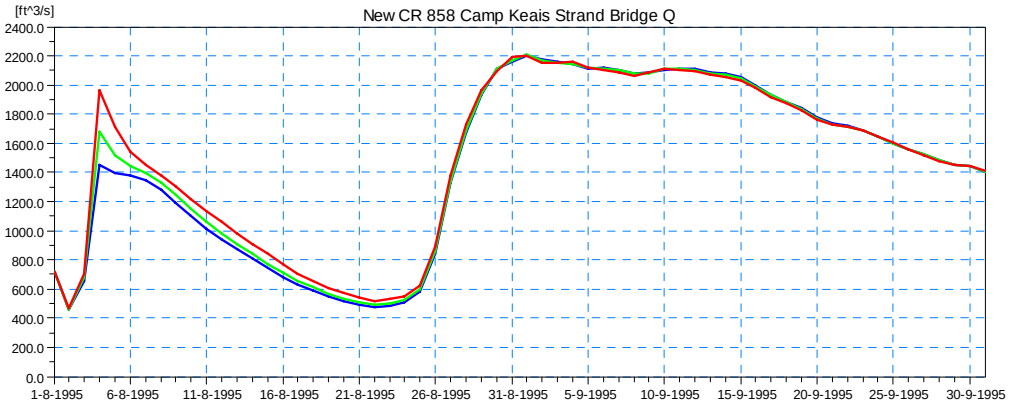

Figure 4.55 Simulated Discharge Results for Scenario 3 at the Proposed Bridge on CR-858 at Camp Keais Strand (Location 1) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

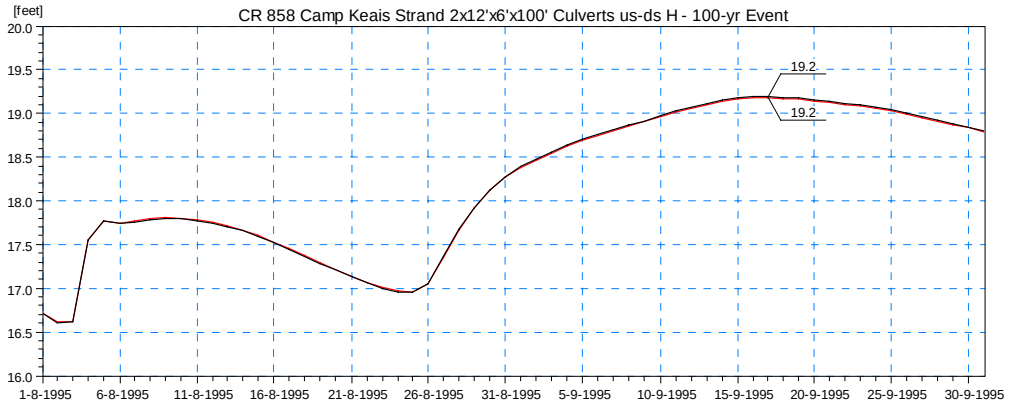

Figure 4.56 Simulated Stage Results for Scenario 3 Upstream (red) and Downstream (black) of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 100-year Design Event.

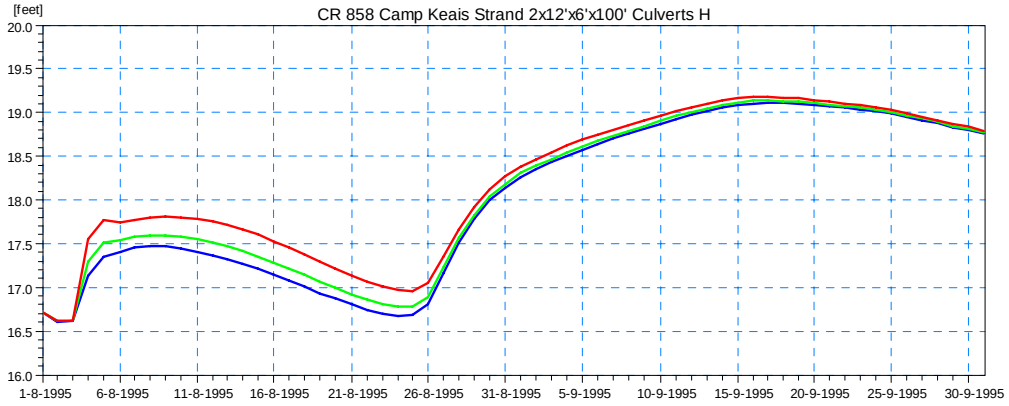

Figure 4.57 Simulated Stage Results for Scenario 3 Upstream of the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

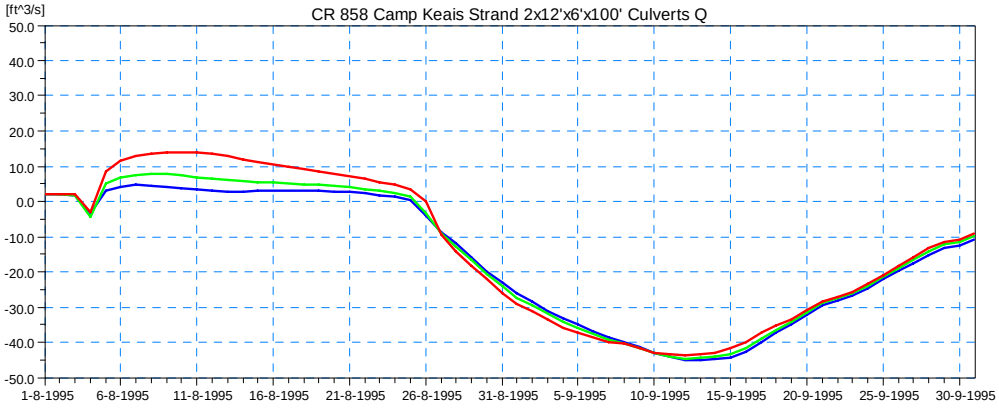

Figure 4.58 Simulated Discharge Results for Scenario 3 at the Proposed Culvert on CR-858 at Camp Keais Strand (Location 2) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

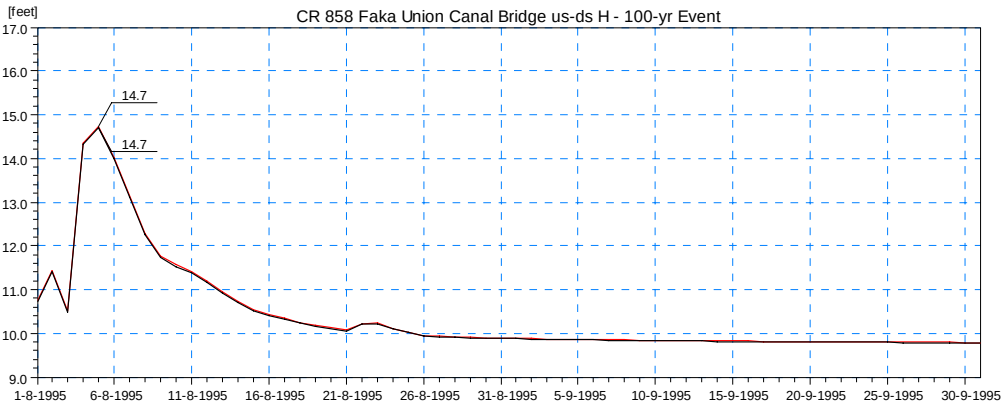

Figure 4.59 Simulated Stage Results for Scenario 3 Upstream (red) and Downstream (black) of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 100-year Design Event.

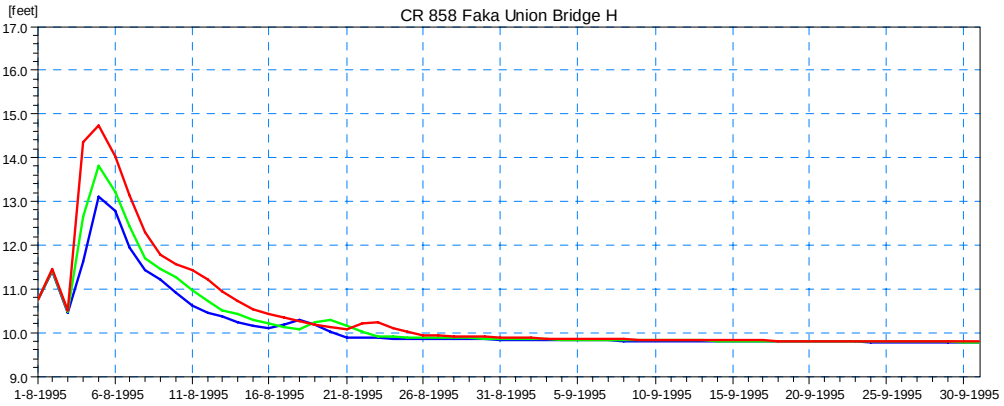

Figure 4.60 Simulated Stage Results for Scenario 3 Upstream of the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

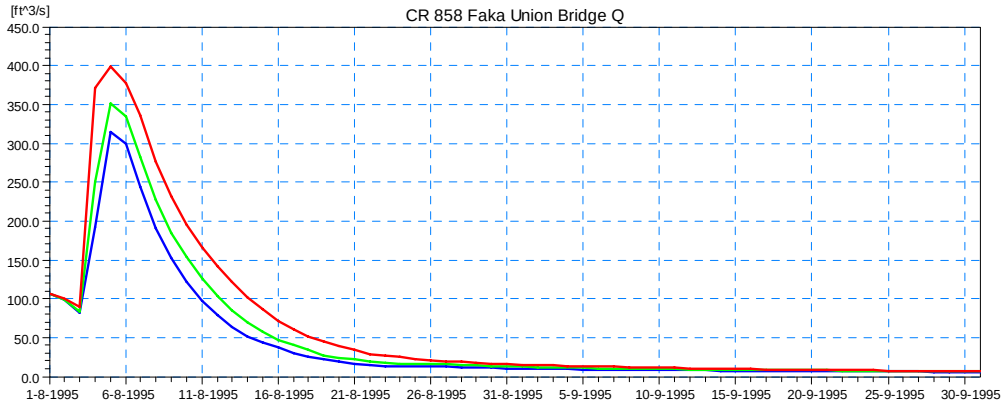

Figure 4.61 Simulated Discharge Results for Scenario 3 at the Proposed Modified Bridge on CR-858 at Faka Union Canal (Location 3) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

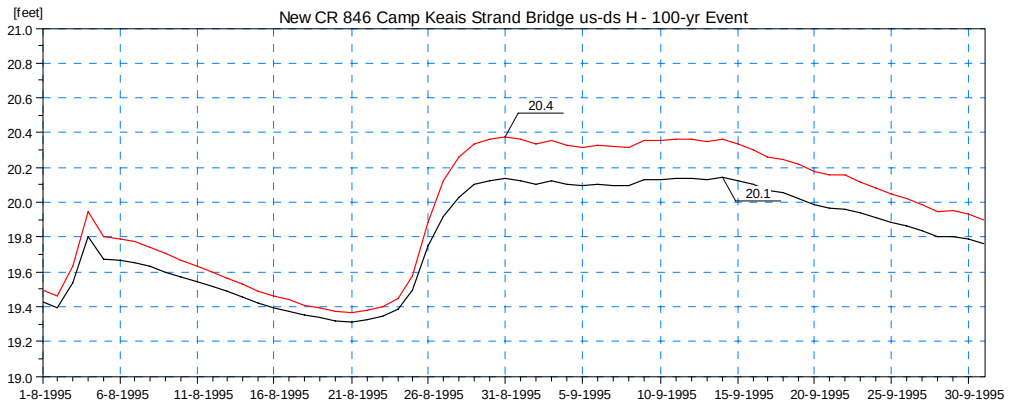

Figure 4.62 Simulated Stage Results for Scenario 3 Upstream (red) and Downstream (black) of the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 100-year Design Event.

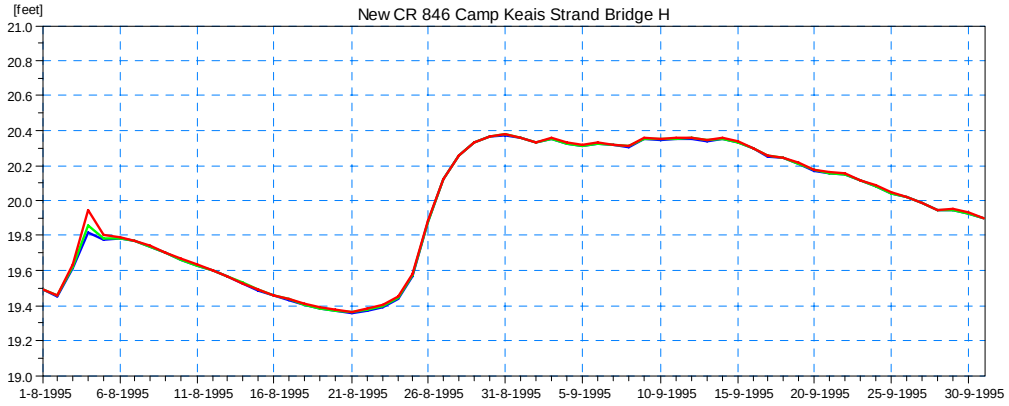

Figure 4.63 Simulated Stage Results for Scenario 3 Upstream of the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

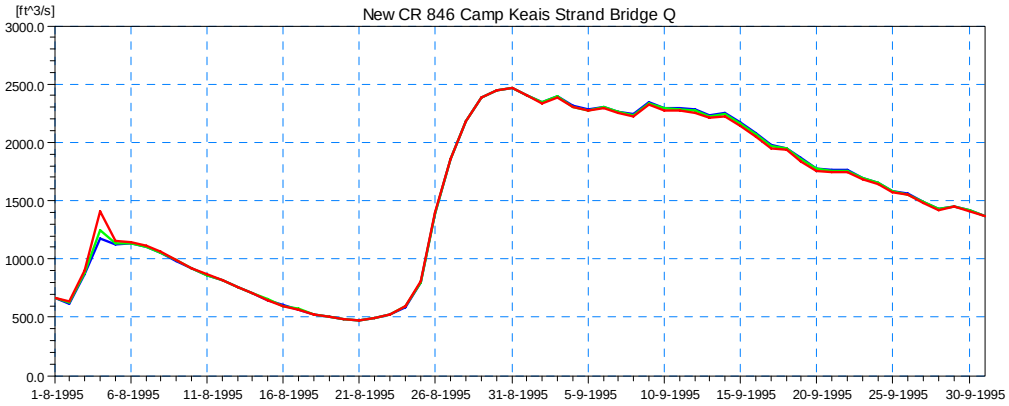

Figure 4.64 Simulated Discharge Results for Scenario 3 at the Proposed Modified Bridge on CR-846 at Camp Keais Strand (Location 4) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

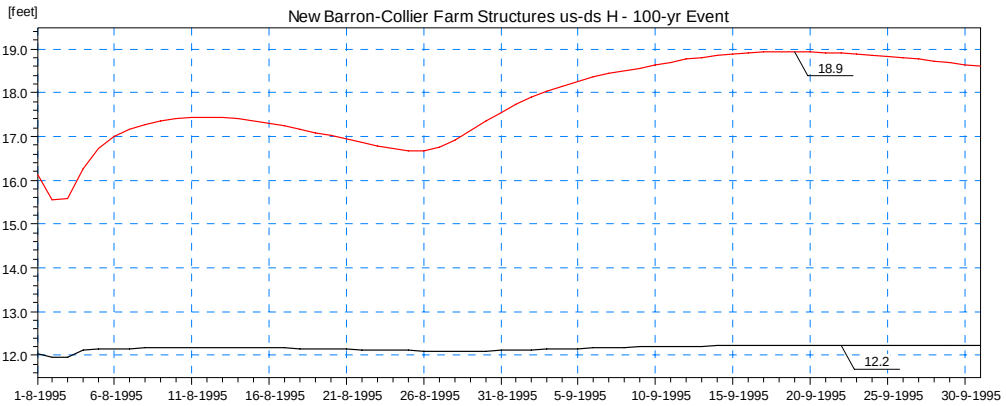

Figure 4.65 Simulated Stage Results for Scenario 3 Upstream (red) and Downstream (black) of the Proposed Modified Barron-Collier Structures in Camp Keais Strand (Locations 5 and 6) for the 100-year Design Event.

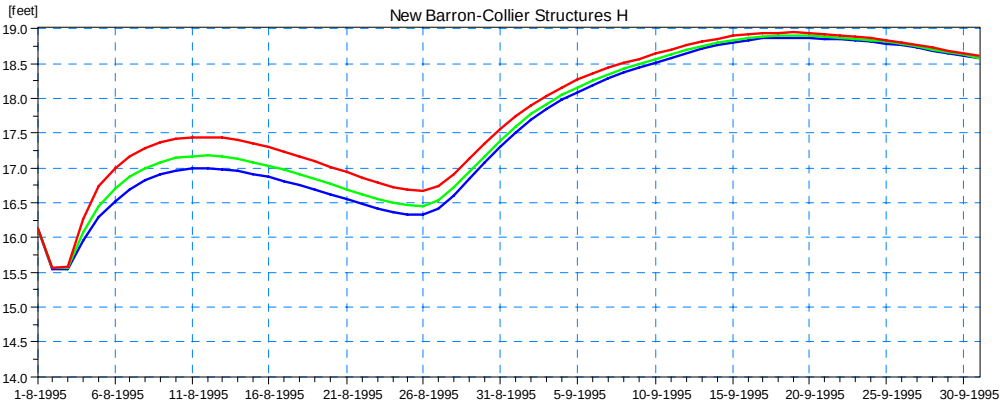

Figure 4.66 Simulated Stage Results for Scenario 3 Upstream of the Proposed Modified Barron-Collier Structure in Camp Keais Strand (Location 5) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

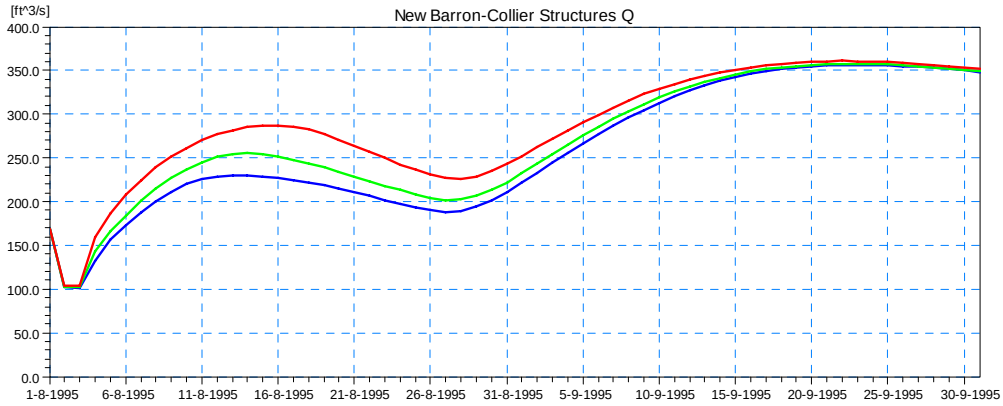

Figure 4.67 Simulated Discharge Results for Scenario 3 at the Proposed Modified Barron-Collier Structure in Camp Keais Strand (Location 6) for the 5-year (blue), 25-year (green), and 100-year (red) Design Event.

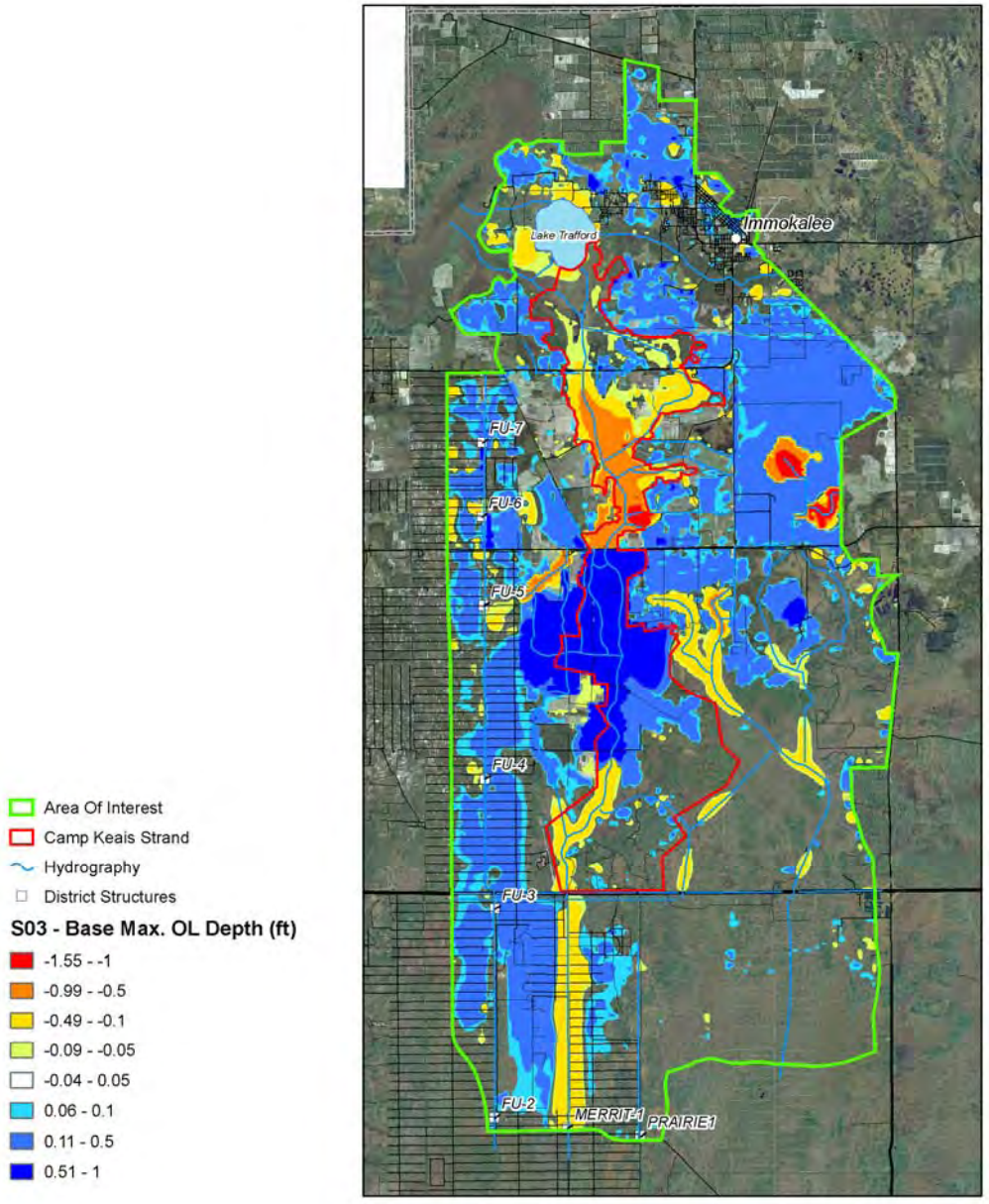

Figure 4.68 Simulated Differences between Existing Conditions (Scenario 0) and Scenario 3 Maximum Overland Water Depths During the 100-year Design Event.

APPENDIX A

COST ESTIMATION DETAIL FOR RECOMMENDED IMPROVEMENTS